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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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The Birmingham Convention.

According to a standard dictionary, a convention is defined as an assembly. The question naturally arises, What good can be derived from an assembly of foundrymen? In the first place, the industry is so unequally developed and is progressing at such a rate that it is essential for all interested parties to keep abreast of the times. Foundrymen have their technical Press, some have local meetings. These factors help, but at an international convention such as has been organised for them at Birmingham they have much more than this. They can actually see and handle the very latest foundry devices. They can meet the most prominent men of the industry. They can hear their problems discussed by the leading men of the trade; and, finally, they can combine business and pleasure in the most effective manner possible. They can visit works or take part in other sections of the conference, with the knowledge that the women guests, too, are enjoying themselves. Further, trade conditions are such that there is little reason for anybody putting forward the plea of pressure of business as an excuse for non-attendance. In the other direction, the excuse that trade does not warrant spending the money is a fallacy, and does not contradict the axiom that to get money you must spend money. Trade is bound to improve, and the foundry, being a key industry, is consequently forced to benefit, whether it be shipbuilding, textile, or steel-making. Obviously it is desirable for the general good of the industry, regarded in its widest possible sense, that as many foundrymen as possible should visit the convention. There will be so much to see and hear that foundry-owners would do well to help their staff by every means in their power to visit Birmingham. If it only stimulates interest in their craft it will be a worth-while effort.

The conditions admit of no argument, as for the first time in British foundry history will there be a really representative gathering, under conditions where participants can interest themselves in every aspect of their calling. As for future conventions, they can take care of themselves, for, once foundrymen have realised how beneficial it is for them to meet under convention conditions, they will demand its periodic full-dress repetition. When it is considered that America, France, Germany, and Belgium have all held foundry exhibitions, and British efforts in the past have been confined to the monopolising of a section in an engineering exhibition, surely it is evident that it is quite time we built up a permanent organisation to this end. No wonder a large section of our industry is so out of date as to warrant the appellation of being essentially antiquated. It is expected that 1922 will see a radical change in this unpleasant type of plant.

Since writing the above we have been informed that the visitors will number well over 300. This is about four times larger than anything which has been held in recent years, and confirms the statement made above that Birmingham is to see the greatest gathering of foundrymen ever held in this country. We quite realise that this is only a small percentage, but it only represents those who are officially taking part. Though the lists are now officially closed, there will be many others who will turn up to the meeting without taking part in the social events.

Foundrymen are specialists as late-comers, as is illustrated by the recent case of a branch secretary, who on the closing date for a works visit found he had only six applications, but actually during the three following days the list swelled to 30. A pleasing announcement is made from Birmingham, that for the International Foundry Competitions there are no fewer than 410 entries.

DR. R. B. MOORE, Chief Chemist of the United States Bureau of Mines, is at present in this country for the purpose of obtaining data desired in various problems of the work of the Bureau along chemical and mineral technology lines.

MR. W. G. ROSE, assistant managing director of the Northern Manufacturing Company, Limited, Gainsborough, died on May 22. He was the son of Mr. William Rose, of Highfield, head of the Albion Engineering Works, Gainsborough.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Installation of Moulding Machines.

To the Editor of The Foundry Trade Journal.

Sir,—The statement of Mr. J. Ellis (reported in The Foundry Trade Journal) that a certain jolt-ramming turn-over machine, costing between £400 and £500, could only equal the output of a small hand-ramming turn-over machine, costing about £30 or £40, makes one realise the danger of too much zeal in the endeavour to promote efficiency in the foundry. It is but natural that the go-ahead foundry manager, after a practical demonstration of the capabilities of a certain machine, should feel that its installation in his own foundry would be productive of good results, and he does not always realise that actual application to a definite end is not quite the same as an abstract demonstration.

The demonstration shows what the machine *can* do, but in this connection it must be noted that the peculiar circumstances associated with a specific business are not taken into consideration. That the machine *can* do what is claimed for it admits of no dispute, but what it *will* do when it becomes but one unit of the equipment of a specific foundry may fall far short of expectation.

In the engineering factory, an automatic machine is not installed if the existing capstan can adequately cater for the demand, for although by the installation of the former the output can be considerably increased, the value of this output does not justify the expense incurred, because it cannot be utilised on account of its preponderance over the production of associated parts. Even if the existing capstan cannot altogether meet the demand, it will often be found better to install another capstan rather than to incur the expense associated with the installation of an automatic machine.

In the foundry, too, an expensive machine must only be installed when it is known that the expenditure will be justified. If after a thorough investigation it is felt that the installation of one or more modern machines will materially improve business, by increasing output and reducing production costs, by all means let them be installed, but let the investigation come before (and not after) installation. The zealous foundry manager is prone to have elaborate ideas, he is so keen upon organisation that he is apt to have an exaggerated idea of the importance of power machinery for the prosecution of his own business. He considers it indispensable to efficiency, and suffers a grievous disappointment when, from one cause or another, application to his own business fails to give the desired results.

The failure may be due to limitation of business, and in this connection it must be definitely established that this cannot be overcome. Often, however, the foundry organisation is not de-developed to the same extent in every branch, and the capabilities of one cannot be fully exploited on account of the inefficiency of another. The efficiency of the organisation as a whole is governed by its weakest point, and it is of no use concentrating upon one point unless the remaining units of the organisation are (or are being) developed to the same degree.

The allocation of labour is an important factor, and it is by no means certain that the degree of skill needed to operate the power machine is as high as that necessary for the hand-operated machine. Modern machines are in the main designed for the utilisation of lower-grade labour, and the point to be considered (apart from an increase in output) is whether the saving on wages will justify the purchase of a modern-power machine. It is assumed, from the statement made by Mr. Ellis, that the wage rates paid to the operators of the two machines were the same, and, if so, it is apparent that the management failed to take full advantage of the innovation.

In many cases improved workmanship is the result of power-ramming, and in certain classes of business this is a decided asset, and as such must not be left out of consideration. It is possible for too fine a product to be turned out for the purpose required, and when this is the case the foundry does not benefit. It may gain a reputation for good work, but where a superfine casting is not really necessary the foundry is avoided by the buyer, because it is "expensive." Where good quality work is, however, absolutely necessary, the power machine will in all probability appear to advantage, and its value as a "getter of business" must on no account be overlooked.

The expense of installing a power machine is only justified when (1) increased output is necessary and there is ample scope for the increase; (2) the labour expenses are less, and this is taken advantage of; and (3) high-class workmanship is essential as a means to ensuring progressive business—and these points should be settled before the installation of the machine is decided upon.—Yours, etc.,

H. W. J.

Handling Repeat Jobs.

To the Editor of The Foundry Trade Journal.

Sir,—In reading the discussion on Mr. Bartlett's Paper on "Handling Repeat Jobs" read before the London Branch of the Institution of British Foundrymen, I notice Mr. Longden is reported to state that a man can hand-ram 110 rheostat grids in a day, 14 in. × 12 in. It would be interesting to know if this man, after making these snap flasks, poured his own iron, undid his work, and riddled the sand ready for the following day.

I was also interested in the letter headed "The Life of Cupolas," and signed by "Silicon," wherein he states that 1,520 tons of iron has been melted and the cupola is still going strong. It would be interesting to know what kind of iron and his recipe for lining a cupola, as I find that a cupola melting hematite iron has to be relined every other day.—Yours, etc.,

"Inquirer."

Mr. McLain to Visit Birmingham.

We are informed that Mr. David McLain is sailing for England by the "Olympic" on June 3. It will be remembered that Mr. McLain was due to lecture to the Birmingham, London, Newcastle and Sheffield Branches of the Institution of British Foundrymen last autumn, but he was detained in the States by an important law-suit, where he appeared as an expert witness. Since the session for the Branches is closed, it is to be hoped that he will be invited to present a Paper to the Annual Conference. As eight Papers are to be given, it is surely possible to extend the programme to nine.

Pacific Coast wants Scotch Foundry Iron.

The Acting British Consul-General at San Francisco (Mr. H. B. Livingston) reports that a firm in San Francisco, California, are desirous of getting into touch with United Kingdom exporters of pig-iron with a view to selling the material on the Pacific Coast of U.S.A. and in the Hawaiian Islands.

It is stated that the quality of pig-iron desired must correspond to No. 3 Scotch foundry and conform to the following analysis:—Silicon, 2½ to 3; sulphur, 0.04 and under; phosphorus, 0.04 to 0.60; and manganese, 0.75 to 1.00 per cent.

The firm are well established merchants, who do a very large business in coal, foundry coke, etc. It is understood that they are prepared either to purchase outright for their own account or to work on a commission basis as agents. They give as reference the Anglo & London Paris National Bank, San Francisco, California.

United Kingdom firms interested in this inquiry can obtain the name and address of the firm in question on application to the Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

The Making of Castings Without Feeding Heads.*

By E. Ronceray, M.I.Mech.E.

An article which the author published in "La Fonderie Moderne" a little more than a year ago on "Castings Without Feeding Heads" has raised great interest in this country.

The translation appeared in abstracts in THE FOUNDRY TRADE JOURNAL, which raised discussions, some of which were getting rather controversial

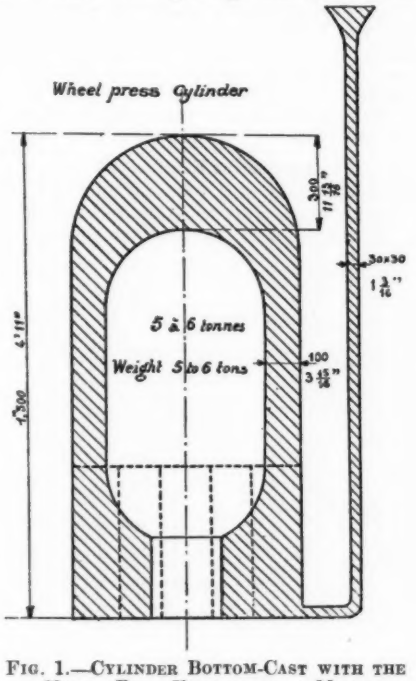

FIG. 1.—CYLINDER BOTTOM-CAST WITH THE HEAVY PART UPPERMOST BY MEANS OF SMALL RUNNERS.

and to which the author finally discontinued to reply, thinking that correspondence of such a nature could not lead to any improvement in understanding. Some of the branches of the Institution of British Foundrymen have discussed the

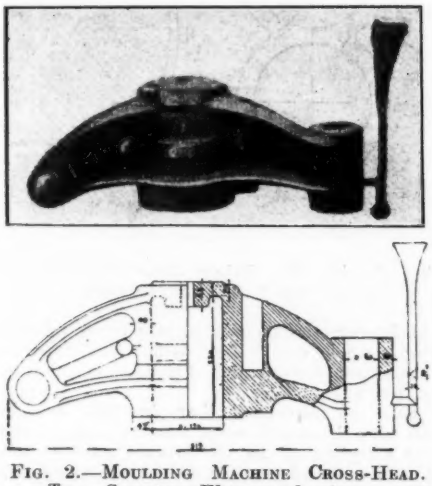

FIG. 2.—MOULDING MACHINE CROSS-HEAD. THE CASTING WEIGHS 3 CWT., THE RUNNERS 8 LBS. THE AREA OF THE RUNNER IS 9/16 IN. SQ.

article, which proves the intense interest British foundrymen took in the subject, and the author has been frequently informed that many foundrymen have made more or less elaborate experiments to confirm or reject the results dealt with.

It is a generally accepted fact that metals, in solidifying, decrease in volume. The best authors accept this fact, and have demonstrated and built on it cooling theories, concluding that in the centre of a cooling metallic mass there must be a cavity.

It may be that this theory holds good for very large masses, but in most of the cases observed in foundry practice the cavities found in castings may be attributed to other causes which a better practice is likely to suppress.

In order to obtain sound castings it is common practice to put on the top of higher parts of them

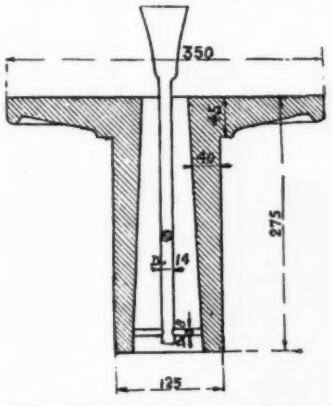

FIG. 3.—MOULDING MACHINE RAMMING PLATE. WEIGHT 81 LBS. WEIGHT OF RUNNER 2¾ LBS. DIA. OF VERTICAL RUNNER 9/16-IN. DIA. OF HORIZONTAL RUNNERS 5/16 IN.

heavy feeding heads, and eventually to use the well-known action of pumping for adding new metal. It is not uncommon to find under feeding heads cavities and porosities. The empiricism of this method does not satisfy progressive men, and the author has some hope that if such men are willing to observe and experiment on the lines that will be outlined, there will be in the near future new laws governing the solidification of metal and the escape of mould-gas, which will

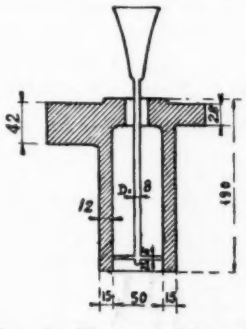

FIG. 4.—MOULDING MACHINE 16 LBS. DIA. OF VERTICAL RUNNER 5/16 IN. DIA. OF HORIZONTAL RUNNERS ¼ IN.

result in considerable improvement, not only in foundry practice but also in other industries, for example, in ingot pouring.

The Origin of the System.

For the first time, a short history will be given of the way that the pouring of castings without feeding heads was originated. This will enable the author not to seem to usurp any longer a paternity which does not belong to him, and to put in its right place a great foundryman, Mr. E. Saillot, one of the managers at the author's works, who is the originator of most of the improvements that the author has had the honour to present during these past twenty years to the foundry world. Mr. Saillot is a man of perspicacity and observation—talents seldom developed in human

* A Paper read before the London Branch of the Institution of British Foundrymen.

beings, possessing as well an instinctive genius for engineering and foundry work.

In about 1886 the foundry of the Western Railway Company of France was engaged in making white-metal brasses for carriage axle-boxes. In experimenting with various ways of pouring them it was found that for some reason, of little weight for the question under discussion, better results could be obtained with a small metal head than with heavy risers. This gave the idea to make tests on gun-metal railway castings in order to

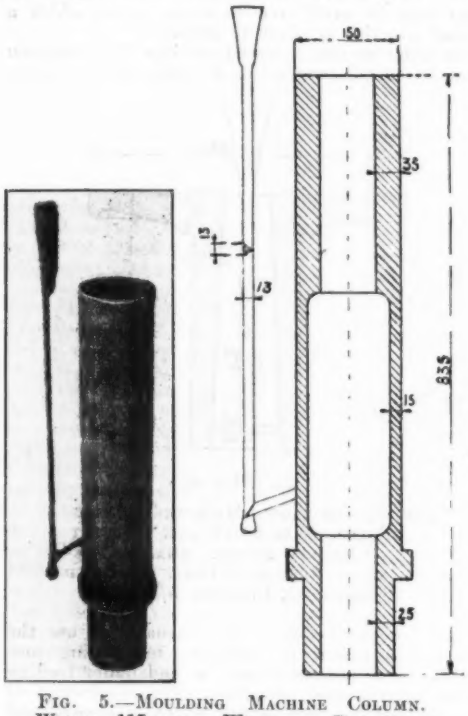

FIG. 5.—MOULDING MACHINE COLUMN. WEIGHT 117 LBS. WEIGHT OF RUNNERS 5 LBS. SECTION OF RUNNER ½ IN TRIANGLE.

reduce feeding heads and risers. Step by step the reduction in bulk took place and pumping was done away with. However, risers plugged by sand still were used, and the runners, though not so large as usual, were of ample size. This went on for a few years

One day, passing through the foundry while a Webb gun-metal locomotive safety-valve body

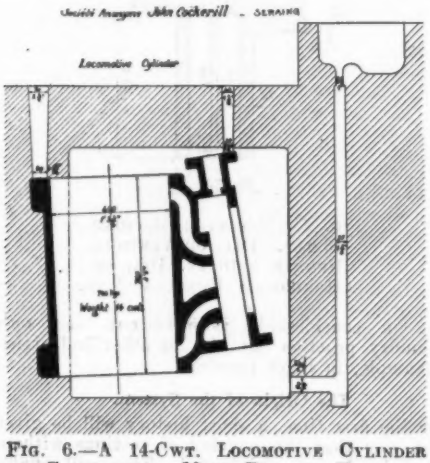

FIG. 6.—A 14-CWT. LOCOMOTIVE CYLINDER CAST WITH A 1¾-IN. RUNNER, ENLARGED ON ENTERING MOULD TO 1 15/16 IN.

weighing about 2 cwts. was being poured, Mr. Saillot, who was manager of the works, saw the men on the point of stopping pouring as the metal did not fill the mould as quickly as usual. One crucible was already poured, and a second one was ready. Mr. Saillot ordered it to be poured. There was not much risk. The mould was condemned and the metal could as well have been poured in it as in ingot moulds. Contrary to the usual practice, the riser plugs did not lift, and there remained in the pouring basin an amount of metal about equivalent to the volume of risers. A perfect casting was the result. It was found in fettling it that the runner was partly closed by a piece of slag which had fallen down from the crucible at the beginning of the pouring. The free section of clogged runner was about ½ in. sq.

Another mould was made without feeding heads, an ordinary pencil being used for making the runner. The result was perfect. The machining revealed no defect, and from this time these castings were made with runners of about ⅜ in. instead of 7/16 in. to 1 in. as before. The method was extended with success to locomotive slide-valves and axle-box bearings.

Hot Pouring Essential

Machine moulding was becoming known at this time. Cliché tables were filled with clichés where feeding heads, as used for hand moulding, were

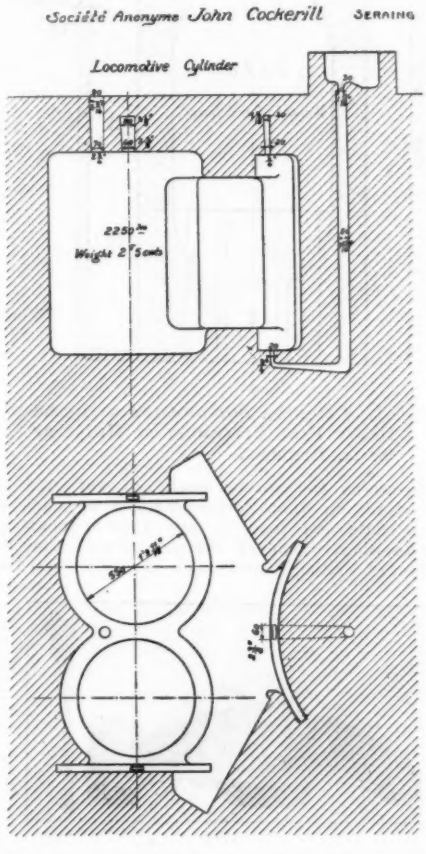

FIG. 7.—A 2-TON 5-CWT. LOCO. CYLINDER, CAST WITH 1 13/16 IN. RUNNER.

provided, and the moulds were poured on end. During a whole month Mr. Saillot had the feeding heads put downwards. The loss was, if anything, less than before.

It must be mentioned that in this foundry moulds were dried and metal was very hot. Later on the adoption of an oil furnace gave trouble until it was found possible to get the same temperature as with clay crucible furnace. This hot pouring is most important, as it was proved in another case.

In the iron foundry of the same company brake blocks, oil boxes, and locomotive cylinders had always been poured without feeding heads—nobody knew why—but all other castings used to be made with heavy heads. The loco. cylinders were poured horizontally with a flow-off that was closed after having let pass 2 to 3 cwts. of iron. However, cylinder covers were poured on end with a large closed riser weighing about as much as the cover itself. The casting was sound, but in polishing it

the metal looked darker near the riser, which can easily be explained by slower cooling at this place. No trouble was experienced by pouring this same casting on flat with a small gate in the centre and no riser.

The resistance of staff and men to such method increased when an order came for three wheel press cylinders, weighing from 5 to 6 tons. But Mr. Saillot insisted, and the first one was poured, heavy part in top, as shown in Fig. 1. The runner was 40 × 40 m/m (about 1 9-16 in. sq.), and no risers or feeding heads were provided. The top came slightly flattened, but was put in regular service without any trouble. The two others were made same way, but with a runner only 30 × 30 m/m (1 3-16 in. sq.) and were perfect. Propelling

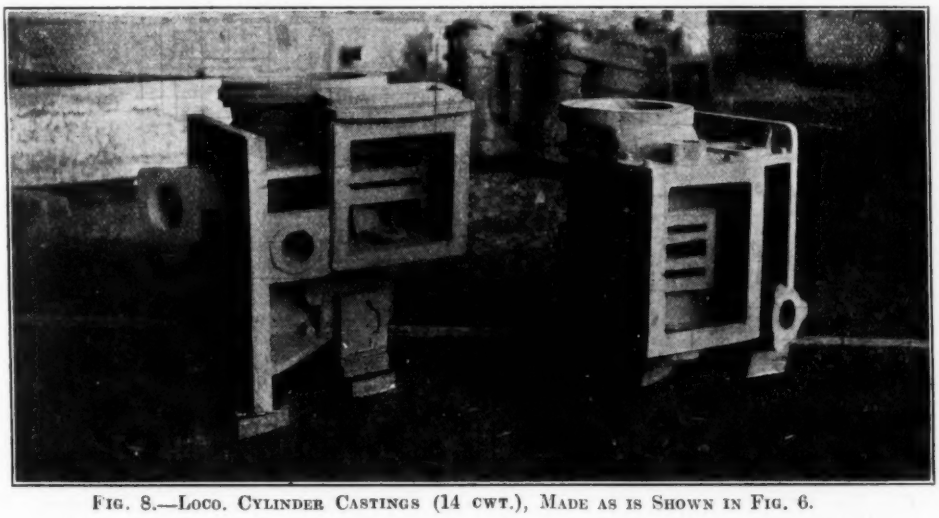

FIG. 8.—LOCO. CYLINDER CASTINGS (14 CWT.), MADE AS IS SHOWN IN FIG. 6.

screws of 9 ft. dia. were made similarly without trouble.

The author had frequent talks on such extraordinary facts with Mr. Saillot, when for business we had opportunities of travelling together, but when in the office there was no time for such speculations, which, after all, were not directly related to the business of the firm.

At this time machine-moulding was principally confined to small castings which did not require feeding heads. Moreover, we had more or less to follow the customers' views referring to the method of gating. We had not at this time obtained sufficient convincing power to impose our own views. The machine moulding was in its infancy, and, as can be imagined, we had enough wheat to grind in our mill with what was related to direct opposition to new processes not to split our efforts in a side line and see the machine accused on this account of all inside shop failures.

However, the opportunity arose during the war when it was necessary to make semi-steel shells with all speed. In order to make immediately shells on machines that were already installed in foundries, we devised a method of moulding on reversible split pattern-plates, and to pour them on end. We recommended doing away with feeding heads and to use for a 155 m/m (6 in.) shell weighing 1 cwt., a runner about ¼ in. We, of course, met a considerable opposition from the War Office, and most foundrymen, but the scheme at last proved satisfactory. Had the moulds been dried no trouble whatever would have been experienced, but it was very advantageous to pour in green sand, and we strongly recommended it. Providing sufficient care was taken in sand-mixing and sand-ramming perfect shells were obtained, and their cost was considerably reduced by the saving in handling coal and metal. However, in the rush, this care was not always taken and troubles were thus experienced. Some foundrymen made shells up to 220 m/m (9 in.) and larger with success by this method, which proves that technically it was satisfactory.

Later on, when our demonstration foundry was put in operation the author tried with alternations of success and failure to produce the same results on different shapes of castings, with the view to determine the causes and obtain data for determining sizes of runners in proportion to weight of castings. However, it should not be considered that the author has fully succeeded to eliminate feeding in every case.

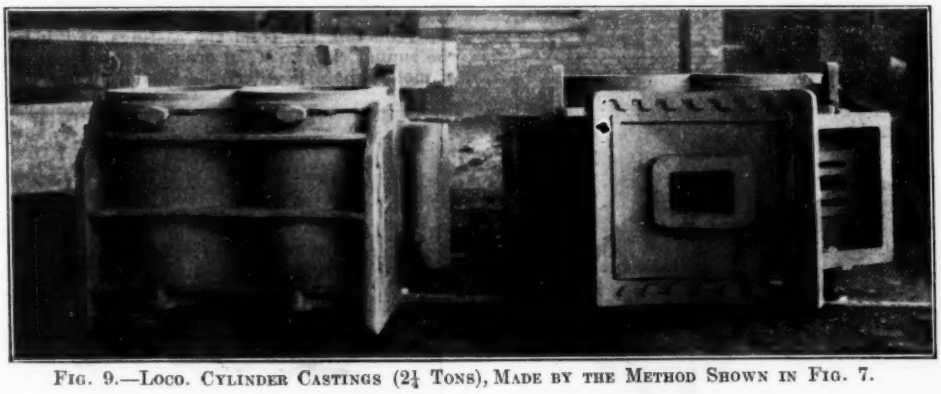

FIG. 9.—LOCO. CYLINDER CASTINGS (2¼ TONS), MADE BY THE METHOD SHOWN IN FIG. 7.

Then it was thought that in publishing the result of these experiments in "La Fonderie Moderne" other people could be induced to take the same course, and from combined experience obtain some increase in common knowledge.

The author wishes to emphasise that this system of slow pouring is not his invention; he has no desire to claim that it is his, though in spite of his efforts it is often called "Mr. Ronceray's System." It is not so.

Since investigating slow pouring it has been ascertained that it is partly used in many shops, though unsystematically. In the Western Railway Works Mr. Saillot found some castings made by a similar process, whilst he himself developed it. At

the Liège Exhibition of the French and Belgian Associations, where visits were organised in local shops, the author discovered that loco cylinders and many other castings were made according to the same principles, possibly through some knowledge of what Mr. Saillot did at Gotteville some years before, possibly for some other reasons. Brunelli, years ago, recommended pouring through small runners about pencil size on the top of castings.

Consequently there is no invention on the author's part, but only an attempt to collect data and to find explanations for facts which are of the utmost interest for foundrymen.

This being well understood, it will perhaps be

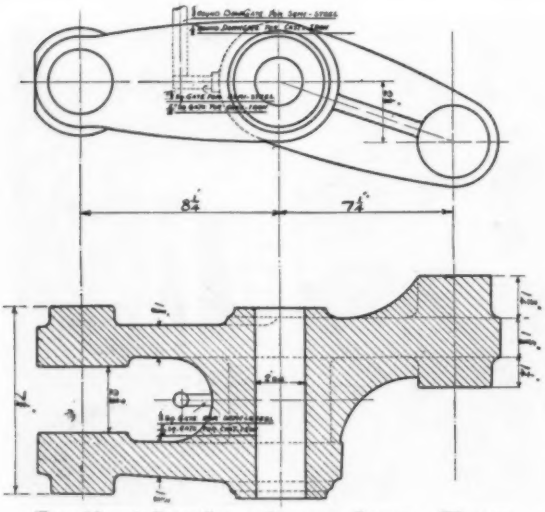

FIG. 10.—A SEMI-STEEL ROCKING LEVER. WEIGHT 1¼ CWTS. DIA. OF DOWN GATE ⅜ IN. AREA OF GATE ½ IN. SQ.

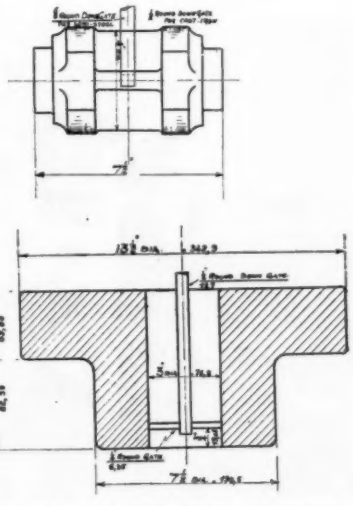

FIG. 13.—A FACE PLATE COUPLING WEIGHING 1 CWT. CAST WITH TWO ¼ DIA. RUNNERS.

advisable to give a short description of a few samples of castings which have been made successfully by slow pouring and no feeding heads. First of all, the castings shown in the original article in "La Fonderie Moderne," which are shown in Figs. 2 to 5.

Some trouble is experienced with the castings shown in Figs. 2 and 3 when proper sand is not used for the cope; it is very liable to scabbing.

FIG. 11.—ACTUAL CASTING MADE ACCORDING TO THE METHOD SHOWN IN FIG. 10.

Similar results are obtained by Brunelli runners used on top of casting.

The top of core, in Fig. 4, being heated inside and outside, is liable to evolve too much gas and produce a waster when the core is not perfectly vented. This casting is now poured on top with a round runner of ¼ in. section.

The author pointed out in THE FOUNDRY TRADE JOURNAL the following conditions in which castings can be made without feeding heads:—(a) When the nature of the casting is such that the gating and cooling can be arranged so that solidification takes place at the same time throughout the casting. (b) That there will be no swelling of the sand, or if there is it will not continue after pouring is completed.

Of course, small runners involve very hot metal. The runners must be kept filled during the pouring so that no air or slag enters into the mould. The slag must always be kept out of moulds if sound castings are expected. There are numerous ways to obtain this result, which too frequently are lost sight of.

Belgian Experiments.

In various papers, Mr. Leonard, confirming the results mentioned, says that slow pouring has the additional advantage of giving more time for the gas to escape. He gives very interesting examples and the author's practice confirms it. He also agrees that when risers are used they must be plugged or otherwise it is not infrequent to find them contaminated with blowholes.

It has been remarked by some Belgian friends, especially Mr. Lamoureux, that their practice differs slightly from the author's sketches in that when they use small runners they manage to have the reduction far from the castings and increase the runner close to it, in order to reduce the speed of metal where it enters the mould. This is quite reasonable, especially when the stream is striking a core or a part of sand. It can then cause scabbing and it is advisable to follow this suggestion.

FIG. 12.—THE CASTING SHOWN IN FIG. 11, BROKEN UP TO EXHIBIT THE SOLIDITY.

Figs. 6 and 7 refer to locomotive cylinders cast vertically at Cockerill Works, Seraing, near Liège. It can be seen that the runner is choked close to the basin and that afterwards the runners are increased. The risers are there for washing the mould. Their section is too small to consider them as feeding heads. This practice is quite common in the Liège district, and this discovery was a great satisfaction to the author. The actual castings are shown in Figs. 8 and 9.

British Experiments.

Amongst other confirmations of satisfactory results from Great Britain the author has received from Messrs. John Musgrave & Sons, Limited, Bolton, the details of a rocking lever which is shown in Figs. 10 and 11.

It is said that previous to adopting this system they were obliged to have a large riser over each of the bosses, also on the body. This meant 4 risers to be fed and cut off by machine. The casting made of cast iron was broken up and found to be absolutely solid and without any signs of sinking on the outside.

A semi-steel mixture with 35 per cent. of steel with the gates slightly enlarged gave the same good results. Fig. 12 shows the casting after

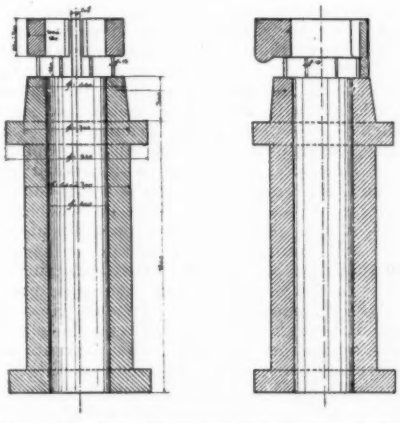

FIG. 14.—TWO SECTIONS THROUGH A 10-TON H.P. HYDRAULIC CYLINDER CAST WITH EIGHT $\frac{5}{8}$-IN. DIA. RUNNERS.

breaking. Another casting made by the same firm is shown in Fig. 13. It is a face-plate coupling, weighing 1 cwt. The diameter of vertical runner is $\frac{1}{2}$ in., and that of the two horizontal runners $\frac{1}{4}$ in.

It is said that previously this casting had to be fed to be solid. No sign of sinking was found; broken, it was perfectly solid and even in texture, and the machine-shop foreman mentioned it was the cleanest casting he ever had to machine.

When visiting works around Liège, whilst the author's attention was already taken up with some interesting castings poured in unusual ways, he was struck at Esperance-Longdoz foundry by a heavy roll lying on the floor, on which traces of only a few small, very thin gates were noticeable.

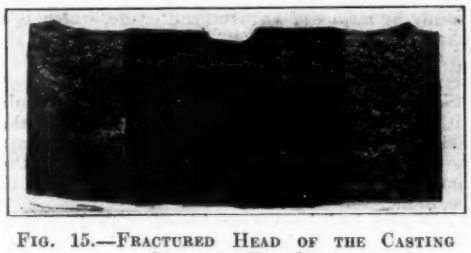

FIG. 15.—FRACTURED HEAD OF THE CASTING SHOWN IN FIG. 15.

The casting weighed about 10 tons and apparently had no feeding head. Moreover, after inquiry, it was ascertained that the part of the casting where the gates were apparent had to be cut out, and a satisfactory reply could not be obtained as to why this part was added to the pattern. The author was informed that the idea was to have more pressure on the casting. It was more likely, however, that it was put there more for safety than for anything else.

The 10 tons of iron were poured through 8 round gates $\frac{5}{8}$ in. dia. Thinking that it would be most interesting to find out whether the head was sound, the author asked the foundry manager, M. Varlet, to split it after having cut it, and to send him a photograph of the section. He was good enough, with the permission of his managing director, M. Stoultz, not only to do this, but also they sacrificed the casting. This casting is shown in Figs. 14, 15, and 16. It undoubtedly is a most remarkable job.

Experiments with Non-Ferrous Metallurgy.

M. Saillot's attention, as previously stated, was first called to this subject by an incident during the pouring of a gunmetal casting. It may be of interest, therefore, to finish this Paper by recounting how a brassfounder, M. Fariner, who recently visited our foundry, having read the original article, carried out some experiments on castings that had previously given trouble. He used small gates with complete success. Mr. Fariner was kind enough to send the author the drawing giving details of their manufacture. The first one was a plain cylinder made of 88-10-2 metal of 13 ins. outside dia. × 6 in. deep × $1\frac{3}{8}$ thick, weighing 77 lbs. It was bottom cast, with two $\frac{3}{4}$ in. × $\frac{1}{8}$ in. runner. The second was a bearing casting made in 86-12-2 metal, and weighed 42 lbs. It was bottom cast by two runners of 19/32 in. × 3/32 in. Both castings were in every way satisfactory.

Many reports of successful experiments have been received from different parts of Europe, but the object of this Paper was to mention some typical ones, with names of works, so that the facts could

FIG. 16.—FRACTURED HYDRAULIC CYLINDER MADE AS SHOWN IN FIG. 14.

be indisputable. No doubt British foundrymen will succeed in many cases if they try by themselves.

The underlying scientific principles are not dealt with in detail because the author is not certain that his hypotheses are right. Suffice to say for the present that it is possible to pour successfully without feeding heads a great number of castings that have been considered impossible to do by this method up to now, and to get them sounder than with the use of feeding heads.

Obviously it is desirable that scientists and practical men should set to work and try to determine causes for such results, which will probably result in the discovery of unknown laws.

In conclusion, the author desires to thank Mr. Greiner, General Manager of Cockerill Works; Mr. Droyart, Superintendent of the Foundries; Mr. Stoultz, Managing Director; and Mr. Varlet, foundry manager, of Esperance-Longdoz Works, for having had the kindness to supply photographs and drawings showing their practice. The author is further indebted to Messrs. John Musgrave & Sons and Mr. L. A. Bentley, their foundry manager, and Mr. Fariner, for having experimented on the lines indicated, and for giving permission to use the documents they so kindly had prepared.

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Single-Phase Electric Furnaces.*

By H. P. Abel, A. A. Liardet and W. West.

The use of the single-phase electric furnace in the metal industry has not been developed to the extent that its advantages really entitle it. The reason for this lies in the fact that a comparatively heavy single-phase load is not an advantage to a 2, 3 or polyphase generator, this being the type of alternating current which is most generally supplied by large power-stations. Small furnaces, such as are used for melting non-ferrous metals, are made of the single-phase type, and their number is steadily increasing, especially in the United States, where the use of the electric furnace for melting alloys of copper, zinc and tin is much more developed than in this country. There are, however, several large single-phase furnaces in operation in this country and elsewhere, and where these are supplied with power from stations having large generating units very little trouble has been experienced. The out-of-balance effect produced by taking single-phase current from a 3-phase generator can be minimised by installing three furnaces, each supplied by current from a different phase, or by using two furnaces with "Scott" connectel transformers, a method of connecting up the transformers to the supply mains, so that power on the high tension side is taken from all three phases, while single-phase current is fed to each furnace.

Rotary machines have been designed and made to take three-phase currents and deliver single-phase. These machines give quite a reasonable efficiency, but they add to the complication of the furnace installation, and therefore are not looked on very favourably. There is no doubt that owing to these difficulties the single-phase furnace, especially for large inputs—300 k.v.a. and upwards—has had to give way to the two- or three-phase furnace. Even in the United States single-phase furnaces are rarely met with, and where they are installed their operation is subjected to stringent restrictions imposed by the power companies. At Buffalo, which is not more than 20 miles from Niagara, with its huge power undertakings, a steel foundry, with three single-phase furnaces, is confined to night working only. This is regrettable, as in a good many ways the single-phase furnace represents many advantages over the other styles.

Details of Furnaces Described.

In the foundry with which the authors of the Paper were connected each furnace has a normal capacity of 30 cwts. of molten steel, although as much as 45 cwts. is often obtained at one tap, when the linings have been partly burnt away. Working continuously over a period of 120 hours, about 170 tons of molten steel in the ladle can be obtained, being approximately 10 cwts. per furnace per hour. The charge consists of cold scrap, mostly in the form of mild steel turnings.

Ease of Regulation.

From a constructional point of view, a single-phase furnace with only one movable electrode, it is almost unnecessary to emphasise the great simplification of the controlling mechanism from furnaces having two or more electrodes. Not only does the actual raising and lowering mechanism consist of one single pinion and rack, but the complications produced by variations in the resistance of one are reacting on the others, as in the case of furnaces with more than one electrode, is entirely absent. With two- or three-electrode furnaces it is necessary to install an automatic regulating-device to maintain each electrode in such a position as to ensure an approximately even distribution of the current between each of them. With the single-phase furnace no such device is necessary, as the burning away of the electrode has no other effect than increasing the length of the arc, hence reducing the amount of energy in the circuit. This can be detected immediately by looking at the controlling voltmeter and corrected by a slight turn of the handle attached to the electrode raising and lowering device. The single-phase furnace, with its single electrode, lends itself admirably to the simplest form of construction, a cylindrical shell with central electrode—simple to build and simple to maintain as regards the lining. This cylindrical form offers the least area of external surface for heat loss by radiation. At first sight this cylindrical form might appear to offer disadvantages for the fixing of the doors, spouts, etc. Steel castings can be attached to the shell to produce the necessary flat surface.

Constructional Details.

The mechanical details of construction in connection with the water-cooling devices for the electrodes is of the simplest nature in the single-phase furnace. It is usual to use a steel conductor in the base of the furnace, one extremity of which is in contact with the actual metal charged into the furnace, the metal thus forming one pole for the arc, the graphitic electrode above forming the other. This steel contact is water-cooled at its lower end, the water service to it being connected in series with the water service to the electrode holder. A loose cooler is placed on the roof of the furnace and surrounds the electrode, so as to cool it and that part of the roof immediately surrounding it. In the ordinary way the gas pressure inside the furnace causes a constant flame to be projected through the space between the electrode and the roof of bricks. The cooler prevents excessive burning away of the electrode at this point. This trouble has been greatly minimised by forming holes in the roof arranged on a circle at some distance from the electrode, through which the burning gas escapes, thereby eliminating the passage of the flames around the electrode. The furnace is mounted on two rockers which rest on rollers, so that the centre of the furnace, as given by the radius of the rockers, remains stationary when tipping. The furnace is tipped by a crank and connecting rod. The circular roof of a single-phase furnace can be readily re-bricked, as taper bricks readily wedge themselves into a circular ring, whereas with a two- or three-electrode furnace the roof is generally rectangular in shape, to accommodate the electrodes, thus necessitating some form of arch template to ensure the bricks being maintained in position.

A single holder, which is fixed to an arm which moves up and down vertically in a channel iron structure which is hinged to the body of the furnace, allows the electrode when raised just clear of the roof to be swung to one side, so that it and the arm supporting it are quite clear of the roof. This allows the latter to be removed bodily and readily by means of an overhead crane, which is a great advantage.

Oyster Roofs.

Some of these same type of furnaces are made with a hinged roof, which can be opened like the shell of an oyster, thereby facilitating charging. In this case the electrode holder is hinged in the same plane, so that the electrode swings back with the roof.

Difficulty had been experienced with this type of furnace in maintaining contact between the bottom of the steel electrode and the metal in the furnace after recharging. This was due to the fact that slag was left in the bottom of the furnace, which formed an insulating layer between the metal electrode and the new material which was charged in. This difficulty was surmounted by making use of a small dummy steel electrode, which is placed in the bottom of the furnace immediately after the charge has been teemed, and which is held in an upright position in contact with the bottom electrode whilst the new material is thrown into the furnace. This gives a satisfactory contact between the bottom steel electrode and the metal in the charge.

If the furnace is to be designed for any given power input it is immaterial, electrically speaking, whether this power takes the form of a relatively heavy current at comparatively low arc voltage or *vice versâ*. High voltage gives a long arc and low voltage a short arc.

* A Paper read before the West Yorkshire Metallurgical Society

Electrical Efficiency.

In the case of multi-electrode furnaces the electrode pressure is, however, limited by the leakage which tends to occur through the refractory roof between electrodes and also by the fact that in furnaces of other than cylindrical design certain portions of the lining which are situated nearest the arcs tend to become over-heated by direct radiation from the arc unless shielded by the electrode itself. Such shielding action only occurs if the arc is so short as to bring the electrode close to the surface of the bath.

The short arc of a low-voltage furnace requires a comparatively heavy current. This means that electrodes of large cross section must be used with relatively heavy usage and expense.

Electrode Consumption.

In single-electrode furnaces where the arc is practically equidistant from all parts of the lining and the possibility of roof leakage is entirely eliminated, a considerably higher arc voltage may be employed, affording the following advantages: (1) Small diameter electrodes, with consequent low-electrode consumption, in the installation with which the authors of this Paper are chiefly experienced, 4-in. electrodes are used in furnaces having a normal input of 400 kw. (600 k.v.a.), and the total consumption of electrodes is no more than 8 lbs. per ton of steel melted; (2) comparatively small cross section of copper in electrical connections, with consequent saving in installation expenses; (3) the possibility of employing reactance control of furnace input.

The last point constitutes perhaps the chief electrical difference between the single-electrode and the multi-electrode furnace, and deserves rather detailed attention.

In the case of any electric furnace of considerable size a certain amount of reactance must be included in the electrical circuit with a view to limiting the extent of the current fluctuations which occur when the arc is unduly shortened, or when, during the melting of cold scrap, the charge collapses and falls against an electrode.

Such reactance is, however, generally kept as low as expedient in order to maintain a relatively high power-factor, with the consequence that considerable current and power fluctuations do occur, and the load-factor over any period of time is therefore poor.

Power Factor Sacrificed or Control

In the single-phase single-electrode furnace the disadvantage of a low power-factor is deliberately incurred, for the sake of the delicate control, and a high working-load-factor which the use of large reactance, in conjunction with high arc pressure, allows.

Transformer Details.

The transformers, by means of which the high-tension supply is stepped down to furnace pressure, are themselves designed with considerable inherent reactance, and, in addition, a large independent reactance can be cut in or out of circuit by means of suitable switch gear. The effect of such reactance is to cause the furnace voltage to reduce rapidly as the furnace current rises, and at the same time to reduce the power factor with increasing current.

Electrical Characteristics.

If the total reactance in circuit is such as to entail at normal load a power factor of 0.7 or less, the effect is to impose an absolute limit to the power or kilowatt-input, so that if the furnace current exceeds the normal the power input will actually decrease.

A diagram giving the result of a series of readings taken under actual working conditions on a furnace of this type, having a normal full load current of 2,750 amps., showed that the open-circuit pressure of 200 volts reduces to about 140 volts at full low-current, while the kw. input rises to 400. If the current is allowed to increase beyond 3,500 amperes the kw. input, having risen to 420, commences to decrease. The fall of kw. input becomes more rapid with further increase of the current, and it is actually possible to short-circuit the arc by feeding the electrode down until it touches the bath, and under these short-circuit conditions the power-input will be something under 150 kw. Current overload equals 50 per cent. amp.

Over the working range of current variation the kw. input remains practically constant at about 400 kw.; in other words, the working range is around the peak and on the falling side of the kw.-input curve.

A series of similar curves illustrate the effect of switching additional increments of reactance into circuit. The three positions of the reactance switch giving maximum power inputs of 420,360 and 325 kw. respectively.

The great disadvantage inseparable from the above form of control is the very poor electrical power-factor, which approximates to 0.6 at normal load. This not only increases the cost of electric supply taken on maximum demand tariff, but renders the load undesirable to an electric supply company, in spite of its high load-factor.

A diagram taken from a recording wattmeter taken during the operation of a heat illustrates strikingly how slight are the power fluctuations. From this it follows that a very high load factor can be maintained. That is to say, the average power-input is a high percentage of the maximum power demanded, a figure of 70 per cent. being obtainable in practice over the working period, inclusive of charging times.

A method of improving the low power-factor which has been referred to is to install in the same power mains as those feeding the furnace transformers either a static phase-advancing plant in the form of a bank of large capacity condensers or a rotary over-excited synchronous motor which will give a leading power-factor, thus tending to neutralise the lagging power-factor created by the furnace and its reactance load.

In the case of the installation with which the authors are connected the demand for direct-current happens to exceed the available public supply, which necessitates the conversion of alternating supply to direct currents by means of a motor generator, the motor of this set consisting of a specially designed synchronous machine of approximately 1,260 k.v.a. nominal capacity over-excited to take a current of 110 amps. per phase at a leading power-factor of about 0.3. This serves to correct the power-factor of the plant, comprising three such furnaces, to approximately 0.8.

Power Consumption.

Furnaces of this type are distinctly economical in power. The figure of 700 units per ton of steel melted from cold scrap is attained, and frequently improved on under conditions of continuous operation, a safe average figure being 750.

Such furnaces can be used with either an acid or a basic lining, but in the case of the latter a lower arc-voltage must be used.

Basic linings tend to suffer from the radiations from a long arc, which the higher conductivity of basic slag and of the atmosphere above it produces with the employment of a high arc-voltage. As an instance of this, the arc can actually be drawn out to a length of 2 ft. over a basic slag before it breaks, the maximum arc pressure at breaking being 200 volts.

Furnace Control.

The control of the furnaces is extremely simple. Owing to the long arc constant manipulation of the electrode feeding-gear is quite unnecessary, even during the melting down of cold scrap. In the case of short-arc furnaces the attendant has to regulate the arc length continuously, if not accomplished automatically.

With a single-phase long-arc furnace, on the other hand, the attendant having struck the arc, adjusts its length till the control voltmeter indicates the prescribed working pressure, and then leaves the furnace until the voltmeter, the reading of which slowly increases as the charge melts down, indicates the correction should be made. This correction is effected by a turn of the electrode feeding hand-wheel bringing the voltmeter back to normal reading. When it is desired to reduce the power-input the circuit is broken by raising the electrode. Additional reactance is then switched in, and when the arc is struck again the volage is adjusted as before, when the

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ammeter and wattmeter will indicate reduced power- and current-inputs.

Speed of Working.

Melting takes place with rapidity. A 400-kw. furnace will melt and finish a 2-ton charge of cold scrap in about 4 hours or under, and is capable of a steady production of upwards of 50 to 55 tons in a working week of five days.

Acid or Basic Hearths.

One of the primary questions which confronts the user of electric furnaces for the production of steel is whether to operate on an acid or basic lining.

This question is invariably decided by a consideration of the product to be produced and the nature of the available scrap supply. The acid process is simple to manipulate, requires less technical supervision, and consumes less electricity than the basic, where more prolonged heating is required to complete the refining operation. On the other hand, with the acid process greater care must be exercised in the selection of raw material, as the ability of reducing the percentage of certain elements in the molten metal is absent.

General foundry practice is distinctly in favour of basic working in the majority of electric furnaces, irrespective of the high cost of basic refractories. This is based on the fact that there is a wide margin of difference between the price of high-grade scrap, which must be used with an acid lining, and the lower grades, which can be satisfactorily refined to produce finished steel to almost any analysis on a basic bottom.

With the high voltage single-phase single-electrode furnace, which is the subject of this Paper, acid lining only has been found to be satisfactory as a refractory material to withstand the severe heat radiation from the high voltage arc.

The single-phase single-electrode furnace works quite satisfactorily on a basic lining, if worked at a lower voltage during refining, say not exceeding 100 initial volts. This would necessitate a higher amperage, with larger diameter electrodes for the same kw. input. On the high-voltage furnace many experiments have been tried with various basic mixtures, such as magnesite bricks, dolomite with 5 per cent. addition of fire clay, dolomite mixed with hot tar, and rammed into position around a wooden template—but none of these linings proved commercially successful.

The best combination which was used consisted of dolomite and pitch reinforced with iron rods at the most vulnerable points of the lining, such as over the doorways and at the nose of the vessel. This lining only gave an output of 32½ tons of steel, after which the furnace had to be completely relined.

The Lining of Single-Phase Furnaces.

Silica bricks of the best quality are used, well kilned to eliminate expansion, and steeped in boiling tar until sufficiently saturated, and then withdrawn to dry. This eliminates all moisture from the pores of the bricks and substitutes carbon, thereby rendering their structure more refractory. Experience has shown that a lining made with bricks treated in this manner has 50 per cent. longer life than one built up of ordinary "white" silica bricks, the life being measured on the actual tonnage of steel.

Around the conical base of the furnace common firebricks are stepped and grouted well together to provide a substantial base for building the working bottom and the lining. Keiselguhr was originally used as a heat insulator to minimise radiation, but was discarded several years ago, being looked upon in the nature of an unnecessary refinement. The furnace bottom consisted of a coarse mixture of half-and-half prepared ganister and calcined ganister rock well mixed with hot tar. This is hand-rammed layer by layer until within a few inches from the top of the steel electrode. On this solid foundation a melting area is built up to any desired size within the limits of the diameter of the shell. The lining above the foundation is built up in such a way as to form an inside veneer of bricks, which can be replaced, after a certain number of heats, without having to disturb the outer and greater portion of the lining. The outer ring consists of standard 2½-in. bricks, tapering to 2 in., so arranged that each wedges itself between the two immediately next. This forms an annular wall 9 in. wide, and is the outer lining which is not touched when the process of veneering is carried out. For the inside or veneer ring specially shaped bricks are used, 4½ in. wide by 4½ in. deep, curved to the radius of the furnace. In this way the lining is built up layer by layer, grouted well together with ground silica brick and fireclay mixed with tar. Large wedge-shaped bricks, called "jambs," are fitted together and inserted to form the charging doors on either side of the furnace, into which the taper plug bricks on the doors closely fit when these latter are closed. This method of forming an inner lining or veneer has proved very successful. After one week's output of approximately 30 heats, this inner lining is just about fused away, and it can be replaced very readily during the week-end.

For the roof taper-blocks are used, which are wedged into the roof frame, which is placed on a wooden template to approximate the shape of the internal spherical arching. This arrangement is commended on account of the simplicity of setting these bricks, which allows of a permanence of structure able to withstand the effects of expansion and contraction following changes in temperature.

Raw Material Used.

After drying a newly-made lining with a coke fire, a charge consisting of metal scrap in the form of clean steel turnings, crushed in a heavy pug mill, is put into the furnace together with 30 to 40 lbs. of ground-up electrode carbon. A representative analysis of such a charge is: C, 0.3; Si, 0.2; S, 0.05; and P, 0.06 per cent. The melted bath will show a carbon content of about 0.4 per cent.

Advantages of Single-Phase Furnaces.

There are two outstanding advantages with the single-phase single-electrode furnace not possessed by multi-electrode furnaces. Firstly, the whole charge, as described above, can be put into the furnace, the plug doors are closed and permanently luted up, avoiding loss by heat radiation, and the finished metal can be teemed into the ladle without any necessity to reopen the furnace. Secondly, during the first hour, what is termed the cutting down period, the electrode is gradually worked down through the charge to form the initial pool of metal, the surrounding partially fused turnings themselves acting as a shield to the refractory material.

Details of Working a Charge.

When this pool of metal is formed the current is cut off from the furnace, and the furnaceman—by means of a long iron hook through the pouring spout—brings the remainder of the charge towards the centre. During the whole process of melting this is the only occasion on which the current need be cut off. The chemical changes which take place in the process of steelmaking and refining in this furnace are entirely similar to those in kindred types working on acid or basic linings as the case may be. When the whole charge is melted the current input is reduced by the insertion of reactance in the circuit—as previously described—and the molten bath is caused gently to boil by means of iron ore additions, which act through the medium of the slag to eliminate the carbon, silicon and manganese. With the acid lining there is naturally no reduction of the sulphur and phosphorus during any part of the working, hence a very rigid observation and control have to be exercised over the quality of the raw material purchased. During the boiling process samples are taken from the bath and subjected to the Eggertz rapid colour test for determining the carbon. Great care is taken to rid the acid slag of all active oxides, to ensure a perfectly reduced condition when the metal bath has arrived at the desired composition. Half the slag is run off from the furnace, and approximately 56 lbs. of limestone is added. This method of introducing a basic material to an acid-lined furnace is contrary to the accepted practice, but has proved very beneficial and satisfactory, neutralising as it does the increased acid nature of the slag derived from the solution of silica which it contains at the high temperatures attained in this furnace. The process of deoxidisation takes place

over a period of 20 to 30 minutes. The usual additions of silico-spiegel are made, followed by the correct additions of 80 per cent. ferro-manganese and 50 per cent. ferro-silicon.

The whole process of melting and refining is under perfect control in the single-phase furnace, both as regards the final temperature of the bath and the rate at which the charge is melted. In charging it is advisable to pile pieces of loose scrap in the centre of the charge, to prevent what is locally termed a "top-melt." If the charge is all turnings, there is a danger of a solid fused mass forming below the first pool of metal melted, which causes the heat from the electrode to be radiated up to the roof, fusing the bricks, which run down into the metal, further increasing the difficulty of melting. The average time from charging cold scrap to tapping 2 tons of finished steel is four hours.

In conclusion, the authors have not the slightest hesitation in saying that where the difficulties of obtaining relatively large quantities of single-phase alternating or unbalanced three-phase current are non-existent, there is no type of electric furnace which is simpler to handle, cheaper to maintain and operate, and more adaptable for general steel electrode furnace.

THE DISCUSSION.

MR. F. ROWLINSON commented on Mr. Liardet's statement that no automatic control was necessary in a single-electrode furnace up to 400 kilowatts, and said he did not think this was necessary in any type of furnace. He had worked furnaces up to a kilowatt capacity very much over 400 without having any trouble at all with the ordinary hand control. Mr. Liardet emphasised a point there which was possibly not quite as fair to the other furnaces as it was favourable to the single-phase electric furnace. Was the continual lifting of the oyster type of roof very detrimental to its life? Mr. Liardet had mentioned that the furnace required re-veneering after 30 heats—approximately one week's work. This seemed to be a very short time, and was probably due to the high voltage. He had made 200 heats very easily without touching the lining in any way, and after re-veneering, had carried a further 100 heats before a new bottom was necessary. He was very much surprised to hear that this furnace was loaded to run at the low power-factor of 0.5 or 0.6. His trouble with electric furnaces had been, as a rule, the power supply companies. In one case, to his very great disgust, he found a power factor of 0.8 severely criticised, and 0.5 or 0.6 would have resulted in a cessation of business.

MR. LIARDET, replying to these and other questions, said they had not replaced their bottom electrode more than once every twelve months, and then it was more a matter of advisability than necessity. The life of the oyster-type roof had not been affected, although they had lifted it regularly to put in large scrap at the top. They could certainly have got more than 30 heats before re-lining, but from an organisation point of view it was very nice to be able to do the re-lining at the week-end, although probably on the Saturday it was good for another 15 or 16 heats.

MR. W. WEST said it was his firm conviction that in making steel castings if they got a good slag they would get a good metal. Metallurgists did not give enough attention to the conditions of the slag.

MR. ROWLINSON asked what was the reason for boiling the silica bricks in tar before re-lining the furnace with them. He had done this, but had not noticed any difference in the life of the bricks as compared with the ordinary ones.

MR. WEST replied that his experience, extending over five years, was quite different from this. They had tried more than a dozen times using a furnace with entirely white bricks, and by Wednesday morning the furnace was down for repairs, much to the disgust of the foundrymen and the works manager. Boiling the bricks in tar left a carbon deposit in the interstices of the brick, and its refractoriness was very much increased. He added that the single-phase furnace was a splendid furnace for making good quality steel.

MR. H. C. DEWS said Mr. Liardet had referred to the ideal furnace as cylindrical, but he thought spherical would be best.

THE PRESIDENT (Mr. T. E. Hull) thought one of the best points brought out had been emphasised by Mr. West—the question of slag balance to the practical metallurgist. If they got their slag right everything else followed. That was the real pivot, and it was the point which probably the bulk of metallurgists had not fully appreciated.

Book Review.

THE METALLURGY OF IRON AND STEEL, compiled by the Editor of Pitman's Technical Primers, published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price, 2s. 6d. net.

This little book is based mainly upon the work and papers of Sir Robert A. Hadfield, who contributes a foreword. We can recommend this book, as its object, as we see it, has been attained, namely, the interesting of all those, even remotely connected with ferrous metallurgy, in the history development, present and future prospects of metallurgy. The perusal of this book cannot help making workers in metals feel proud that they are connected with an industry which has done so much for civilisation. The book is divided into eight chapters, the first of which deals with "conservation." This is very interestingly set out. It is shown that whilst coal is completely used up, iron is capable of re-use, less losses by oxidation, but we were rather surprised that the author makes no mention of the almost inexhaustible quantities of aluminium available in the shape of clay—once an economical process can be found for its extraction.

Chapter 2 is one which should specially interest those who wish to follow the history of their craft. There is given in an appendix a list of all the early workers, starting with Aristotle and finishing up with Wöhler, who was born in 1880. Those coming after him are acknowledged in the text. We were interested to find in this list the names of Leonardi da Vinci, the artist, who is credited with having introduced the blast for melting iron, and Emanual Von Swedenborg, the theologian, who wrote on iron. It may interest foundrymen to know, that there was presented to the library of the Cast-Iron Research Association, the first work on mineralogy ever printed in English (if the statement contained in this book is correct). It was written by Richard Kirwan, of Dublin, who was born in 1733. Other chapters follows dealing successively with iron ores, and the manufacture of iron and steel. Hardening, heat-treatment and microstructure. It should be explained that no micro-photographs are given, the idea being to show its object and utility and not the actual practice and theory. Alloy steels, fuel economy and research, are other subjects dealt with in a general, rather than a particular manner.

The book concludes with a lengthy appendix outlining the 131 scientific papers and addresses given by Sir Robert Hadfield, and it is interesting to note that whilst many of them have been read dealing with matters of vital interest to foundrymen, apparently he has never addressed the Institution of British Foundrymen (of which he is an honorary member), and unquestionably the Institution is the poorer for it. It is a situation which needs remedying.

German Industrial Conference.—Some 1,200 of the leading Industrialists of Germany held a three days' conference in Hamburg, under the auspices of the Reichsverband der Deutschen Industrie (German Industrial Union). The President of the Reichsverband, in his inaugural address, spoke in pessimistic terms of the future of German industry. It seemed, he said, as if business activity, both at home and abroad, were going to stagnate. Many circumstances which had hitherto favoured a more or less brisk export trade had ceased to exist. The purchasing power in the home markets was no longer able to keep pace with increasing prices, due to the depreciation of the mark and the shortage of raw materials. When German industry had to compete with world market prices, many people would realise that Germany was an expensive country, with high costs of production, and it was doubtful whether Germany would then be able, as she was now, to employ 60 per cent. of her productive forces, or be able to permit her workers the luxury of a general eight-hour day.

XUM

The "Wilson" Blast Recorder.

The production of consistently sound castings necessitates careful supervision of the material fed into the cupola, not only with regard to quality but also as to quantity. It is common practice to weigh the coke, iron, etc., as it is put into the cupola, but the most vital factor, intimately affecting the resulting product, namely, the volume of air fed into the cupola, is generally left to chance.

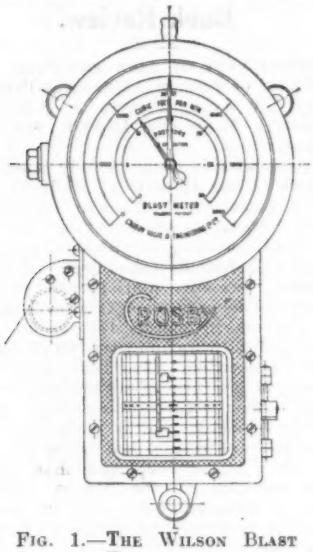


FIG. 1.—THE WILSON BLAST RECORDER

It is futile to expect to reproduce the same conditions day after day if care be exercised only with regard to some of the factors in a process whilst others more vital to successful results are uncontrolled.

It is often assumed that a pressure gauge is sufficient to enable the amount of air to be gauged, but this is entirely erroneous. The pressure gauge on a boiler gives no indication of the amount of steam passing the stop valve, and likewise a pressure gauge on the air main is no guide to the volume of air passing the cupola.

The volume of air, and therefore the amount of oxygen entering the cupola, depends upon the pressure of the blast and also upon the resistance which it encounters in its passage through the mains, tuyeres, and through the interstices of the charge in the furnace. These latter obstructions will vary continually with the state of the furnace, so that even though the blast pressure be raised the amount of air passing may actually decrease.

It was for the purpose of solving this proposition, with which, of course, is allied the kindred proposition of minimum coke consumption, that the Crosby Valve and Engineering Company, Limited, of 41, Foley Street, London, W., introduced the Wilson blast recorder. This apparatus, illustrated in Fig. 1, which automatically indicates and records the pressure and the volume of air passing into the cupola, is covered by Patent No. 140217 of May 25, 1920.

The temperature resulting from the combustion of 1 lb. of average coke (88 per cent. carbon) to CO_2 is 2,590 deg. C and to CO 1,490 deg. C. Therefore, if, owing to an insufficient supply of air, the efficiency of the cupola be reduced, fuel is wasted. On the other hand, excessive supply of air and high pressure have a serious oxidising effect on the iron.

Pressure gauges on cupolas are common, but as indicators of air in passing through the tuyeres are not only useless but misleading. An increase in pressure is often due to resistance in the cupola or tuyeres, and the volume of air is therefore actually reduced. Obviously, air to the cupola should be measured by volume, not by pressure.

It is obvious that the resistance in a cupola must vary throughout the "heat." The first iron is often considered unsatisfactory, but in proper practice this should not be so. Further, if the admission of air is regulated by rule of thumb the last iron brought down is not only liable to be oxidised, but most of the burning out of the lining takes place at this period.

To obtain the best results, therefore, the blast should be regulated to obtain a constant volume of air throughout the heat, and this can best be done if the operator has before him a chart or indicator showing continuously the volume of air passing into the cupola.

Fig. 2 shows the details of the actuating mechanism. This consists of a pivoted balanced lever carrying a disc inserted in the path of the air or gas which is to be measured. The deflection of this disc, in currents of varying velocity, must obviously follow a well-defined law, and the amount is easily calculable, giving a velocity factor which can be used in conjunction with the area of the main to determine the quantity of air passing. This deflection is transmitted by means of a flexible cord to a quadrant mechanism in the interior of the recording portion of the instrument, and by means of a pen arm is transmitted to a suitable calibrated chart mounted upon a cylindrical clock drum. These charts, as usually supplied, give a continuous record over any pre-determined period, which can be hourly, daily, or weekly, depending upon the type of clock drum. The charts are usually arranged to give a twenty-four hour daily record.

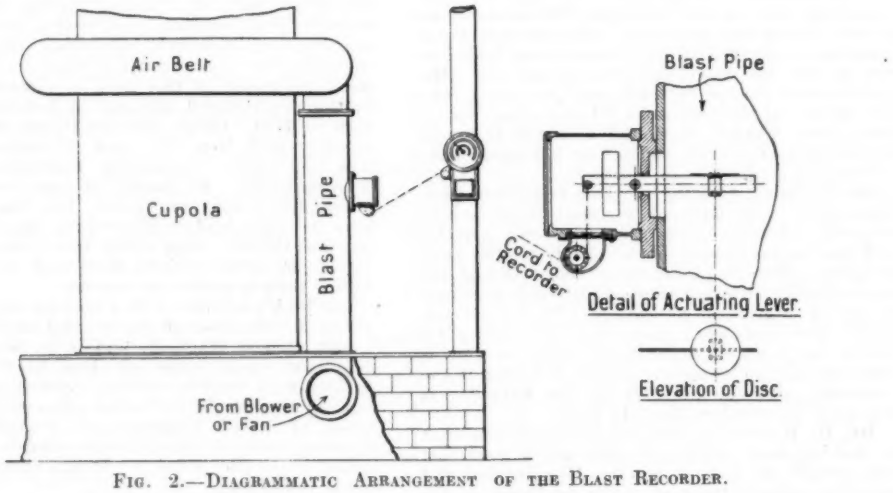


FIG. 2.—DIAGRAMMATIC ARRANGEMENT OF THE BLAST RECORDER.

In addition to the volume recording pen and pointer there is a second pen arm actuating from a second quadrant mounted upon a spindle concentric with the spindle of the volume recorder.

This second pointer and pen make a simultaneous record of the pressure in the blast main, which pressure is transmitted by means of standard aneroid bellows.

It will, therefore, be seen that this recorder is purely mechanical and does not depend upon the "Pitot" or similar principle. It will work in dirty air, which is, of course, of considerable advantage.

The chart provides a permanent record for the use of the foundry manager and metallurgical staff of the working of the cupola.

The two pointers for pressure and volume are the indicators to the cupola operator that he is working his blast correctly, supplying the exact quantity of air at the exact pressure.

The effect of excessive or insufficient supply of air upon graphitic carbon, silicon, and manganese—three most important elements in cast iron—is serious during the melting operation. Many foundries pay the price for high-grade material, but through inefficient control of the air supply to the cupola in which these materials are used the analysis is changed to such an extent that the resultant metal is totally different from that anticipated, with a consequent result in many cases of defective castings and excessive coke consumption

Knowing that the raw material is of standard specification, the cause of these failures must be looked for in other directions, and in many cases the most experienced foundrymen are baffled. A high percentage of these failures can be, and has been, traced to inefficient cupola practice when thoroughly investigated.

For instance, certain gases are formed in the process of re-melting which are most injurious in castings and which can only be eliminated at certain temperatures. A mistaken notion amongst some foundry men is that to obtain a hot metal free from gases more coke should be used.

Foundry coke to-day is an expensive item, and it is sometimes used to excess. This not only adds to the cost, but, in most cases impairs complete combustion, thus adversely affecting the temperature and the quality of the resultant metal. The capacity of fan or blower does not necessarily give the required amount of air of the tuyeres. Frictional losses, etc., must be taken into account. A modern recorder such as that described will at once detect any obstruction or reduction in size of air belt or tuyere area. The amount of air generally accepted as necessary to melt one ton of iron is 30,000 cubic ft.

The relative positions of the blower or fan (these differ considerably in their action in cupola practice) and the cupolas which it supplies, the direction and general design of the air-supply main, and the number of bends have an appreciable effect upon the actual amount of air available at the tuyeres.

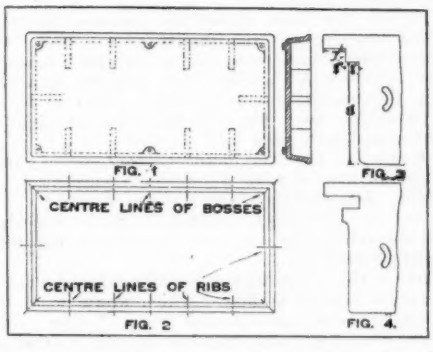
It is well known that theoretically 1 lb. of carbon burned completely to CO_2 requires 12 lbs. or 150 cubic ft. of air at normal atmospheric temperature and pressure and develops 14,500 B.Th.U.'s, whilst 1 lb. of carbon burned to CO requires 6 lbs. air and develops only 4,500 B.Th.U.'s—hence an excess of CO in the gases represents a large waste of heat.

Moulding a Base Plate from a Strickle.

BY W. PYATT.

There are numerous medium and large castings to which the strickle system could be applied with much saving in cost, taken as a whole, and not as separate departmental costs. It is the general system to adopt strickles for circular or semi-circular castings, but there are numerous instances where strickles could be used on other types of castings, as, for example, base plates or castings where the moulder can have a straight run on the sides and bottom with a flat joint for the frame.

One baseplate which came to the writer's notice some time ago was a "one-off" job, "very urgent," and low priced. The size of casting was 8 ft. × 4 ft. × 8 in. deep, with internal ribs and bosses and facings on the outside, as shown in Fig. 1. To mould this, strickles were made, the procedure being as follows:—A template was provided 5 in. × ¾ in. sections, the inside measurement of the frame must be the same as the outside measurement of casting at its widest part, and the top side when moulded (Fig. 2). An inside strickle (Fig. 3), a thickness strickle (Fig. 4) must be prepared, together with the necessary strengthening ribs and bolting-down bosses in the form of loose patterns. All centre lines for ribs and bosses must be clearly marked on the frame, after which the empty bottom-part moulding-box (if any) is set on the floor. An ash bed is prepared inside for venting and the mould is rammed up to the box edge with riddled floor sand. A level bed is then struck; if, however, the box edges are true they will serve instead of straight edges, and the frame is then placed in position on the level bed, and staked below the top to allow the strickle to pass over. The strickle shown in Fig. 3 is now used taking care to get a hard face on both sides and bottom. The sides should then be damped and dry parting sand rubbed on, and the strickle run gently along to remove any surplus. The ribs and bosses are now set in position according to centre lines on the frame, after which the frame can be removed without disturbing the stakes. The inside of the pattern can now be left, and after the top box has been placed in position the moulder can now gagger and ram up in the usual way, taking care not to displace the ribs or bosses. After removing the top box, replace the frame in the stakes and use the thickness strickle. Here a strickling allowance of ¾ in. can



be allowed for facing sand, but the writer has obtained good results from the black floor sand up to 1 in. metal. After strickling, remove the frame and stakes and finish the mould in the usual manner. The question of gates and risers must be decided according to design of base plate. A first-class casting can be produced in this way, the comparative cost being:—

Full Pattern.

Patternmaking	... ...	65
Moulding	... ...	25
	Total	90 hours.

Strickles.

Patternmaking	... ...	12
Moulding	... ...	30
	Total	42 hours.

Additionally there is a 60 per cent. reduction in the amount of timber used, and consequently less pattern storage involved. There is hardly any limit to this method for this class of casting. The example given is a simple one, but the system can be used for single, double, or even treble limbs, and shape or weight is no obstacle.

The only drawback is the extra cost on the foundry which the foundry manager naturally resents, where it is only departmental. But where it is recognised that the foundry and pattern-shop must study the firm's interest and plan the job as a whole, then there is no question that the method described is by far the cheapest. There are other advantages as against the block pattern, such as correct and equal thickness of metal, no core-irons, no bolting of the cores if in the top box; studs are not required if the cores are set in the bottom half.

XUM

Institution of British Foundrymen.

CUPOLA FACTS, FACTORS AND FANCIES.

A joint meeting of the East Midlands and Sheffield Branches of the Institution of British Foundrymen, held in Sheffield, took the form of a visit to the Brown-Firth Research Laboratory, where the visitors were received by Dr. W. H. Hatfield.

At a meeting in the Cutlers' Hall at night MR. A. POOLE, of Stoke-on-Trent, gave a lecture on "Cupola Facts, Factors, and Fancies." When one considered the many varieties of cast iron which were required from the foundrymen of to-day, said Mr. Poole, and the important part the cupola played in their production, the need for a standard type of cupola, with standard practice, embodying the maximum of efficiency and economy, became apparent. It had been said that the standardisation of cupola practice was an impossibility. With so many types of cupolas in existence this might be true, and would probably remain so until the best features of these numerous types were embodied in one perfect apparatus. The attention of those engaged in research work was, no doubt, focussed on these important matters. Experiments under laboratory conditions, however, were not quite satisfactory. To be of the utmost value they should be carried out under practical working conditions, and the responsibility for the erection of the finger posts to perfection lay with the foundryman himself.

One of the most important factors for good cupola practice was the quality of the fuel. The demands of foundrymen for a standard foundry coke of definite chemical and physical qualities from the manufacturers did not appear to be an unreasonable one. The qualities required might be summarised as follows:—

Chemical:—The maximum percentage of fixed carbon associated with a minimum percentage of sulphur, ash, and moisture.

Physical:—Strength combined with porosity, high calorific power, and more important still, high calorific intensity.

Coke of the following composition might be taken as a good average standard which would meet the requirements of most foundrymen if they could secure consistent and regular supplies:—Carbon 90, sulphur 0.5, ash 7 per cent., and the rest water and other impurities.

Coke Ratio.

After discussing a coke of this quality with regard to melting ratios, Mr. Poole said the principal source of loss was the incomplete combustion of the fuel in the charge. From analyses of the waste gases taken just below the top of a cupola charge it had been estimated that only 52 per cent. of the carbon in the fuel was completely burned to CO_2, the remaining 48 per cent. being burned to CO in the charge, changing to CO_2 above the charge. This represented a loss of about 34 per cent. of the potential heat contained in the carbon which formed 9/10th of the coke, or approximately 37 per cent. from the total weight of fuel.

The question naturally arose as to whether some method could be devised for utilising the surplus and potential heat contained in the gaseous products issuing from the charge. A modern blast furnace had many points in common with the cupola, and there was no apparent reason why some of the methods which had resulted in so much greater efficiency and economy with regard to blast-furnace practice should not be applied to the cupola. The adoption of the closed top with the cup and cone charging arrangement, or some modification of it, and the utilisation of the waste gases for pre-heating the blast, drying ladles, cores, etc., should not present any insurmountable obstacles, and the advantages were evident, especially with large cupolas running long heats. The cup and cone method of charging ensured a practically perfect distribution of the charges, an essential factor for perfect working, and if the temperature of the blast was raised only a few hundred degrees Cent., the results should justify the initial expense. Another source of loss in cupolas where the molten metal was collected in the hearth was the excessive amount of coke necessary to form the bed.

Is Wet Coke Advantageous?

The idea of saturating coke with water before charging was open to criticism. It was claimed that this treatment had the effect of keeping the upper part of the charge comparatively cool, thus concentrating heat in the melting zone, with consequent quicker melting and less combined carbon in the metal by the time it reached the melting zone. The temperature of a cupola at the charging door was high enough to evaporate the moisture in the coke in a very short time, probably before the charge had descended more than a foot. It was difficult to see how any appreciable cooling effect could be exercised by the relatively small amount of water absorbed by the coke, even in the proportion of 2½ cwts. to one ton of iron. Dealing with the question of air supply, Mr. Poole said that for the greatest efficiency it was necessary to supply to the cupola an adequate volume of dry air, pre-heated if possible, delivered at sufficient speed and pressure to ensure its even distribution over the whole of the cupola area, and to obtain the maximum calorific value and intensity from the fuel. The question of blast pressure was intimately connected with the quality of the fuel. The most important characteristic of foundry coke was its calorific intensity when burned in air. The temperature factor in cupola practice could not be emphasised too strongly. It was also of vital importance for the efficient and regular production of semi-steel. The generally accepted theory with regard to the melting of steel was that the steel absorbed carbon from the coke, thereby lowering its melting point sufficiently to melt at cupola temperatures, the implied assumption being that the cupola does not attain to temperatures sufficiently high to melt steel without this action taking place. This appeared to be fallacious, and in his opinion it might be definitely asserted that good semi-steel of regular composition could not be produced from a cupola unless the temperature of the melting zone was above the melting point of the steel.

Temperature of Melting Zone.

The temperature of the melting zone of a cupola working normally was easily high enough to melt mild steel. In a Paper read before the Institution at the Blackpool Annual Conference, Mr. G. K. Elliott said, "There is good authority for assuming that the temperature of the hottest part of the melting zone is about 2,200 deg. C." This was probably an over-estimate, said Mr. Poole. No firebrick or fettling would stand up to anything approaching this temperature under cupola conditions; but it was practically certain that temperatures of 1,600 deg. C. and even higher were nothing out of the ordinary for a cupola working at its best. Having no means of taking the temperature of the melting zone while the cupola was in operation, he recently took a series of tests of the coke from the melting zone when discharged from the furnace ten minutes after the blast had been shut off. The average temperature of the coke was just over 1,350 C. It was reasonable to assume that these temperatures, taken outside the cupola, would be at least 250 deg. C. below those inside the cupola at full blast. Nearly all the carbon absorbed by steely mixtures, or any cast iron, was taken from the coke bed after the metal was melted. The number, disposition, and dimensions of the tuyeres were governed by the size of the cupola, and the blast pressure. The tuyeres were better kept at one level. The effect of an upper row was to raise the melting zone, and consequently the coke bed, which led to increased coke consumption. If the air supply was insufficient more tuyeres should be added at the same level, or the capacity increased.

Internal Form of Cupola Important.

Another factor which had an appreciable effect on the melting efficiency was the internal shape of the cupola. A lining which tapered outwards slightly from just above the tuyeres appeared to

give the best results. The height of the charging door from the cupola bottom was a factor which deserved more attention than it usually received. In many cases the height had been fixed so that the least labour and expense might be involved in lifting the materials to the charging platform. Modern mechanical appliances, however, had rendered this consideration a comparatively unimportant one. Any increase in the charge depth would have the obvious effect of utilising a greater proportion of heat, with a corresponding increase in the temperature of the charges before reaching the melting zone.

The weight of each charge of iron which could be efficiently melted was governed principally by the fuel ratio, and the capacity of the melting zone. The amount of slag-forming material charged into a cupola had an appreciable effect both on fuel economy and loss of iron. This material consisted chiefly of the ash in the fuel, and the sand and oxide of iron attached to the pig iron and scrap. The average loss of heat due to the formation and melting of the slag had been estimated at about 8 per cent., producing 65 lbs. of slag per ton of iron melted. Obviously, any reduction in the amount of slag-forming material charged led to further economy. Most of the pig iron cast in Great Britain was cast on sand-beds, and the presence of sand on pigs cast in this manner was unavoidable. Whether it would be a paying proposition or not to remove the sand by sand-blasting the pigs, he was not prepared to say. The onus, however, should not be on the users of pig iron, but on the makers, and the solution lay in following the American practice of casting the pigs in cast-iron moulds. Pig iron cast in this manner would be chilled to a greater or lesser degree, but the composition remained practically unaltered, and when re-melted in a cupola, the resultant metal would have approximately the same qualities as a similar pig cast on a sand bed.

Sand v. Chill-Cast Pig.

A further important consideration was that the thermal resistance of a chill-cast pig was far less than one cast on a sand bed. An appreciable amount of heat was required to break down the thermal resistance of the thin skin of sand attached to a sand-cast pig. The weight of sand charged per ton of pig iron averaged about 20 lbs. This value could be ascertained from any brand of pig iron by weighing a few samples of the pig and noting the decrease in weight after sand-blasting. Assuming that coke was used containing 6 per cent. ash and that the melting ratio is 2 cwts. per ton of iron, the amount of slag-forming material in the coke equalled 12 lbs., which, with the sand adherent to the pig iron, using half pig and half scrap, gave a total of, say, 20 lbs. of slag-forming material to be fluxed per ton of iron. Assuming this to be silica (SiO_2) and that all of it was fluxed by lime (CaO) to form the silicate $CaO.SiO_2$, the amount of limestone to be added could be easily calculated from the formula:—Sixty lbs. of silica requires 56 lbs. of lime, which are contained in 100 lbs. of limestone. Twenty lbs. of silica would therefore require 33⅓ lbs. of limestone. As the ash of the coke was to some extent self-fluxing, and as a proportion of the silica was fluxed by oxide of iron, the amount of limestone added was usually less than the proportion given.

Influence of Atmospheric Conditions Inside Cupola.

The atmosphere of a cupola in good working order might be taken as practically neutral, or only slightly oxidising. Very little, if any, of the oxide of iron charged was reduced to metallic iron. The greater proportion of it found its way into the slag, either by combination with the sand and ash, or with the silica in the lining materials. On the other hand, the only appreciable oxidation of iron which took place in a cupola running normally appeared to occur in the vicinity of the tuyeres after the metal was melted. The molten metal collected in the hearth was protected from the oxidising action of the blast by the slag which floated on its surface. The amount of iron in the slag was mainly dependent on the amount of oxide of iron charged, and it would be more accurate to describe "loss of iron" as loss of sand and rust. It might also be safely assumed that the removal of silicon and manganese occurred principally after the metal was melted, and was largely due to the presence of oxide of iron in the slag and oxide of iron occluded by the metal itself, although it was probable that some manganese was removed by combination with sulphur. The conditions were very similar to those which prevailed during the manufacture of malleable iron by the "wet" puddling process, where molten metal was subjected to the influence of a slag, rich in oxide of iron.

The life of a lining was adversely affected by the presence of iron oxide, which attacked the silica in the fire bricks or fettling, with the formation, in many instances, of appreciable quantities of quite unnecessary slag. The reduction in the slag output when using pig iron and scrap, free from rust and sand, was very noticeable. Two trial heats recently melted, one of 5¼ tons and one of 6 tons, using pig iron previously sand-blasted, and scrap shell-plugs with an anti-corrosive coating, resulted in a total output of slag and refuse averaging just over 30 lbs. per ton of iron melted.

Silica Cupola Linings.

It was a mistake to use inferior fire-bricks for a lining, which should consist of the best silica brick available with the joints as close and tight as is practicable. The cement and fettling used should be as nearly as possible of the same composition as the brickwork. Given normally good bricks it would be found in most cases that the joints and the jointing materials were the principal sources of weakness. If a silica brick was used in conjunction with a cement or fettling containing much alumina or oxide of iron, chemical action was nearly certain to take place between these compounds and the silica of the brickwork, with the result that the life of the lining was considerably shortened. Three per cent. of iron oxide in a silica brick was stated to be sufficient to make it fusible. At high temperatures silica caused expansion, and provision should be made for this when lining a cupola with high silica materials. In some cases a small space was left between the shell and the lining, which was filled in with a refractory sand. When associated with silica the tendency of alumina was to cause contraction. The acid silicates of alumina are stated to be more fusible than the basic. The melting point of pure alumina is given as 2,050 deg. C., and that of pure silica as 1,750 deg. C. to 1,800 deg. C., although the latter was open to criticism as to whether it was the true melting point or not.

In conclusion, said Mr. Poole, the point should not be forgotten that low coke consumption was not the only end to be attained. Hot and rapid melting was of equal, if not greater, importance, and good castings could not be produced unless the metal had the proper amount of superheat. The true melting ratio was not the weight of coke per ton of iron produced from the cupola, but the weight of coke per ton of good castings.

A resolution of thanks was accorded Mr. Poole for his lecture, this being proposed by Mr. John Watson, the President of the Sheffield Branch. Mr. Evans, the President of the Derby Branch, seconded, and referring to the Paper, suggested that if they could get the makers of pig iron to come more into line, he thought the majority of their troubles would be overcome.

SHEFFIELD BRANCH.

SOME PERPLEXING FOUNDRY PROBLEMS.

"Some Perplexing Foundry Problems" was the title of a Paper read by MR. J. SHAW, of the Brightside Foundry and Engineering Company, Sheffield, before the March meeting of the Sheffield and District Branch of the Institution of British Foundrymen. Mr. John Watson presided.

The Paper was originally read by Mr. Shaw at the Blackpool Conference, and a report of it has already appeared in our columns.

The Discussion.

THE CHAIRMAN said they had listened with pleasure to Mr. Shaw's remarks, and he would be very glad to hear the views of the members on the points he had raised.

Oxides may be Present in Cast Iron.

DR. SWINDEN said he desired to congratulate Mr. Shaw on the extremely interesting way in which he had asked his questions, but at the same time he hoped it would be realised that it was much easier to ask questions than to answer them. He would not like to attempt to answer completely any of the four questions. In regard to "oxygen" mentioned in the synopsis of the Paper circularised, he thought it was generally agreed that there was no evidence whatever that oxygen as such was present in either iron or steel, but that iron oxide existed most probably in the form of a solid solution was he thought definitely proved. He had not studied the data in regard to iron particularly, but in regard to steel that view was now generally accepted. He was not present at the function at which Dr. Hatfield made the statement referred to by Mr. Shaw, and if it was made without any qualification he (Dr. Swinden) was rather surprised, because he saw no reason whatever why oxide of iron should not exist in the presence of 1.3 per cent. of silicon. Oxide of iron would be formed on high temperatures. It was well known that where iron and steel contained considerable proportions of manganese and silicon the Fe Mn and Si would be oxidised in certain ratio according to the temperature and to the supply of oxygen. He thought it was safe to state that iron oxide could be formed and remain in the metal without assuming the complete prior oxidation of silicon. In the case of manganese it was quite definitely proved that the reduction of iron oxide by manganese is a balanced reaction and that it was impossible to completely de-oxidise with manganese. The problem was difficult, because of the difficulties in the way of an accurate method of estimating oxygen in its several states of combination in the metal. The work of Pickard and others had been very carefully carried out, but he still thought that the Ledebur method did not give results of practical value in attempting to determine the effect of oxygen or oxides on either iron or steel. He did not think that anyone would suggest that the analysis shown by Mr. Shaw was complete, because it ignored the oxides. Then there was the important question of nitrides. He accepted Mr. Shaw's statement that the quality of a casting depended upon the quality of the iron and that re-melting did not necessarily put all iron into a uniform condition. To explain exactly why this was was a matter of extreme difficulty. One met with exactly the same thing in regard to Swedish iron. If the possibilities of explaining that difference are traced out, taking the case of Walloon and Lancashire bar iron, it is found that one essential point of difference is that the Walloon blown with a cold blast and the Lancashire iron was blown in a pre-heated blast. He (Dr. Swinden) had previously mentioned at these meetings that in Sweden a blast furnace working under certain conditions had given iron which was quite satisfactory as regards analysis, but the resulting steel in the open-hearth process was not so good as when the iron was made with cooler and lower pressure blast. One feature that might explain that was the possibility of the influence of the nitrides and also possibly the influence of hydrogen. There had been practically no work done in hydrogen. That hydrogen could be occluded in very large quantities had been proved, and it was still an open question what affect ordinary deoxidisers had upon hydrogen. In regard to nitrogen there was a difference of opinion as to how it exists, but there is good evidence to show that nitrides are formed which are stable. He suggested to Mr. Shaw that the content of nitrides, oxides, and possibly even hydrides would have a bearing on that difference in results quoted. In the case of nitrides it was quite possible that even re-melting would not eliminate their influence. He would not attempt to discuss the question of test bars, but it seemed obvious that more work was required in that direction. With regard to the British Standard specifications, his experience was that they were most reliable and workable, and the Committee were always anxious to receive suggestions to improve them and make them what they should be—that was a series of reliable tests to control the quality of the articles which were ordered to these specifications.

The Shape of Test Bars.

MR. JOHN R. HYDE said he was very pleased indeed with the way Mr. Shaw had dealt with the subject. As a foundryman, however, he could only say that when doctors differed it was a very awkward position for the patient to be in. After the discussion on oxygen and the whole question of analysis, they were absolutely in a fog. It was interesting, however, to see the effects on the two series of iron that Mr. Shaw had published and to know that they were not by any means freak irons. They had been manipulated by the same people over 60 consecutive days. When they obtained results like that one had to look round for some other condition than analysis. Dr. Swinden had told them they had to look for other things. As foundrymen they had made tremendous strides in foundry practice, and had induced men to take an interest in analysis, but when it came to nitrides and the like he was prepared to leave that to the Research Association and let them explain some of the differences. With regard to test bars, he supposed they would have to put up with them more in the future than in the past, but they had always the idea that cast iron was distinctly erratic on test. With the tensile test they had been able to work with reasonable consistency, and if they machined the transverse tests the results were also reasonably consistent. But then was introduced the whole question of variation in casting temperature and in the type of mould. He would support the round bar machine as a distinct advance in consistency. But no one was going to disregard altogether the tensile bar. Any of these suggestions that were put forward were really in the interests of both sides of the question. They would be a help to the inspectors, most of whom admitted that cast iron was a difficult subject, and it would be a help to the foundryman.

Tensile Tests Preferable.

ENGINEER-CAPTAIN MOORSHEAD said he was prepared to take exception to what Mr. Shaw had said about the lax manner of stating the results of tests. As far as the Admiralty were concerned they were particularly definite in the qualities required in the case of cast iron under test. The British standards laid down three distinct areas for test, and presumably they were so arranged as to be the most applicable to the job as long as the necessary 11 tons tensile was obtained the Admiralty were satisfied with the metal. He did not know whether in cast iron everybody's wishes could be met, and he considered Mr. Shaw was too sweeping in his statements. Mr. Shaw apparently wanted to wipe out the tensile test. That was destructive criticism, because he thought the tensile test was a very useful one. If the designer of, say, a steam cylinder was deprived of his tensile test and had to rely entirely on another—presumably more of a shock test than anything else—he did not know where he was. All steam cylinders should have the tensile test, and to suggest wiping it out was a retrograde movement. If he (the Captain) could get 11 tons on the tensile he would be satisfied. He was inclined to believe Mr. Shaw had a little bit up his sleeve, and would perhaps give further information on tests.

Satisfactory Puddled Bars Contain Oxygen.

MR. T. D. ROBERTSON, of Sydney, Australia, said he regretted he was not able to be present at the meeting at Blackpool at which Mr. Shaw's Paper was read, and therefore he welcomed that opportunity of being present to hear the subject. When the question of oxygen was introduced to him some time ago he got an idea which he had never had a chance of proving by actual experience. But the idea he had got hold of was that the bad effect of oxygen in iron or steel was largely a question of temperature at which that iron or steel was exposed to the oxygen. If they took, for example, the making of rod iron which was made under extremely oxidising conditions at a very low temperature—it was really below its melting point—oxidising conditions did not appear to have any bad effect. With regard to the test-

ing of cast iron, he noticed that the subject of temperature had not been referred to at all.

Does Oxygen Close Grain of Pig-Iron?

MR. E. ADAMSON said it was well known in blast-furnace practice that certain forms of iron oxide were more refractory than others. He thought it was possible that iron oxide could exist in pig-iron, and did not think it was wise for anyone to say that simply because there was a certain small percentage of silicon present in pig-iron that oxide of iron, if present in pig-iron in that form, could not therefore exist. He thought, moreover, before it could be definitely settled whether the increased strength of pig-iron was due to the presence of oxygen a very great deal of further investigation was necessary, because increased percentages of oxygen appeared to coincide with closeness of fracture, which in itself denoted strength. It was yet to be proved that the presence of oxygen or oxide of iron caused this closeness of grain, and in his opinion this closeness of grain was due to thermal conditions in smelting. Too many conclusions have been drawn in the past from varying percentages of one impurity. What applied in the laboratory did not always apply in works practice, and when both chemical and physical conditions were disclosed other conclusions could be drawn than variations of one impurity. It was not one thing which had to be taken into account, but a whole series of influences—for instance, Cook's two tests referred to by Mr. Shaw of 9.1 tons and 18 tons from the same analysis was one of the proofs of this.

He agreed that oxygen was difficult to analyse for, and he thought the presence of oxygen or oxide of iron and its influence, and also the difference between Numbers 1, 3, 4 and other fractures of pig-iron was subject-matter which was well worth serious research and very stringent investigation. In 1910 he was showing the late Mr. Hailstone a piece of a 2 in. × 1 in. transverse test bar which was very close grained, and asked him to give his opinion of the silicon contents; the reply was about 1.50 per cent., and he would not credit the statement that it was 3.00 per cent., consequently he wished to investigate. From Mr. Hailstone's letter, dated May 11, 1910, he gives Si, 3.051; S, 0.042; P, 1.098; and Mn, 0.688. This test-bar gave 32½ cwts. and 0.60 in. deflection on 3 ft. centres—hardly a test which would have been expected from such a high silicon bar, and it was no isolated instance of this test from similar analyses, but one regularly obtained.

Cold Blast and Refined Irons are Strong.

With regard to the physical properties of iron, they spoke only of facts when it was stated that cold-blast iron and that refined in the Siemens furnace were stronger physically than hot-blast irons, not because of the analyses, but for some other reason outside of this. He thought there could be no cause of dispute about this. Dr. Swinden had referred to the statement that the present method of analyses was incomplete and that differences in tests would be explained by taking a complete analysis. In his (Mr. Adamson's) opinion, this suggestion was merely talking round the subject, and he did not think Dr. Swinden would accept this position when he himself spoke of the differences in physical properties of pig-iron from Swedish charcoal furnaces merely by changing the method of working; therefore if such a physical difference is possible in what might be termed a "baby" blast furnace, how much more will it apply to the more modern furnaces producing 20 or 30 times as much pig-iron—or possibly even more—per day.

Low Silicon Grey Iron.

Mr. Shaw had referred to his (Mr. Adamson's) sample of pig-iron with silicon 0.35 per cent. and a perfectly grey fracture, as those present had seen when the sample was passed round. The accuracy of the analyses had been questioned, because it did not conform to the established theory which assumes that the iron should have been white, but such an objection is no argument. The sample and analyses were given to him in 1905 through the kindness of Sir Robert A. Hadfield, and they would agree that those in his laboratory responsible for the analyses would not allow an improper one to be issued.

Chemical Analysis Less Important than Physical Properties.

The emphasis of these physical differences in cast iron, as Mr. Shaw pointed out, is not an attack on the chemist, although it has been continually taken as such. Unfortunately, many chemists who have been trained to make analyses—which did not control iron foundry metallurgy—have begun their works experience with the idea that it did, and many Papers have been given on that score. The physical properties of pig-iron, however, are due to other causes primarily, and are only modified by chemical composition. In a recent issue of the "Chemical Trades Journal" (dated October 31, 1921) was given an extract from Vol. 41, pp. 1285-1293, of "Stahl und Eisen" for 1921 as follows:—

> "The physical properties of the pig-irons are more important for successful working of the Thomas process than the chemical properties."

It is a fact that certain basic irons are preferred to others, not on the grounds of analyses, but on the results obtained.

With regard to the machining of test-bars, he was glad this had been mentioned, as he had shown in a Paper published before the Iron and Steel Institute in 1910 that machined bars gave fully 10 to 15 per cent. better results than those tested as cast—taking into account the exact section of the bar. He believed in the transverse bar, because it gave three different kinds of tests, tensile, transverse and deflection; and if these were worked out to the moment of resistance, as shown in the Paper just referred to, the engineer knew exactly what was desired just as well as the tensile would disclose.

In 1910 he remembered seeing the results, before publication, of an investigation by Meyer, of Wintertour, on different sized test-bars, published before the International Testing Association at the Copenhagen Congress of 1910, but he felt then there was much more work required before it could be definitely decided which shape and size of bar was the best for *British* practice, as it did not follow that what suited American conditions suited ours, and they thought they themselves should undertake on a very serious scale the duty of deciding what test-bar would be best for British requirements.

THE AUTHOR'S REPLY.

MR. SHAW, in his reply, said he was pleased to hear that Dr. Swinden agreed that it was possible both oxygen and probably other occluded gases might have serious effects on the structure of cast iron. In this respect he was as one with the present Director of Research (J. E. Fletcher). Mr. Adamson, in his remarks, confirmed a theory long held by Dr. Moldenke, namely, that the effect of oxygen on cast iron might not be a direct one, but by its influence on the carbon, causing the balling up of the graphitic portion into fine particles instead of the usual plates. Personally, he thought, if the conclusions of Cain and Pettijohn were correct, there was only one thing to do, namely, to devote all energies to finding a more simple and correct method of determination than any at present in use. It seemed useless to form any opinions if the analysis was open to suspicion. Coming to the question of variation of strength in cast iron of the same composition, he was sorry no one had taken this point up more strongly, because it was a vital one. After allowing for all cooling effects and the minute variations in some of the elements, would anyone venture to say that these were the cause of a 50 per cent. increase of strength for 60 consecutive days. After eliminating all other factors, the only variation they knew of, was the fact that on the day one iron run out, and was replaced by a new one to give the same ultimate analysis, the strength went up from 10.7 tons to 15.8 tons, and maintained that for the remaining 60 days. He had also submitted to them actual samples, showing the great variation between analysis and structure. It was open to any member to take two of these samples away with him and remelt them in any way they liked, providing they were not melted above cupola tem-

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peratures and also not held at a high temperature for a long time, but when melted cast into a sand mould, as the iron would be in the foundry. If these conditions were observed there would be no recovery of structure, and an iron containing T.C. 3.24 per cent., C.C. 0.25 per cent., Si 2.89 per cent., Mn 0.95 per cent., S 0.027 per cent., P 1.31 per cent., would still have the close fracture as at present, and would not recover when remelted to the open crystal fracture of a No. 1 that would be expected from the analysis above. Nor would the 0.35 per cent. and 0.18 per cent. silicon irons on remelting under the same conditions show the mottled or white fracture expected, but still remain grey. There can be no outside element not accounted for in two of these samples, because we are using irons at the moment from the same furnace and ores, which are normal in all respects. Chemical analysis is not at fault, but the lack of knowledge of temperature effects in the blast furnace, due to irregular working, etc.; facts well-known to blast furnace managers. He would have been pleased if more expression of opinion had been voiced as to the advisability of using one size test-bar with varying loads for different thickness of castings or three different size bars, the latter to bear some relation to the thickness of castings they represented. Like himself, Mr. Hyde was in favour of the latter method. Captain Moorshead, in his spirited criticism, preferred the tensile bar. No foundryman would quarrel with him on that point, as it was more easily made than the transverse. In reply to Mr. Robertson's question as to the temperature at which the 60 bars were cast at, no actual tests were taken. In every case it was good hot metal. If he would consider that little variation in the results of the tests during the first 60 days, and it was only on changing the iron in the last 60 days' test that the large increase in strength took place, he would realise that temperature was not the dominating feature.

LANCASHIRE BRANCH.

Discussion on Mr J. Wood's Paper on Cupola Practice.*

MR. H. SHERBURN said Mr. Wood had covered the problem of cupola practice very fully, but perhaps the lecturer would give his views as to the relative merits of the drop bottom and the solid bottom type of cupola. Another fruitful source of controversy was whether a double row of tuyeres was better than tuyeres disposed on one level. To what height did the lecturer advocate charging the coke above the top row of tuyeres? It would be very useful to have a chart giving the weight of charge for different internal diameters of cupolas. He supposed all cupolas were arranged more or less to suit local conditions, but the tendency to-day was to confine the melting period as much as possible in order to allow more time for moulding. The reduced hours of labour made this an important matter. Many cupolas, which under pre-war conditions were sufficiently large for their purpose, were now too slow for the purpose. The difficulty, however, with large cupolas operating over a shorter period was that the greater volume of coke would increase the total coke consumption. The balance of cost was under present conditions favourable to the larger furnace.

What was Mr. Wood's ratio of coke to iron? Dividing the total consumption for a week by the number of tons of iron melted, what was the total amount of coke per ton over the week and the amount of coke per charge? In these days of high cost fuel that was a very important matter and sufficient attention was not given to it except in foundries where the cupola practice was highly organised. In some places a coke balance sheet was drawn up every week, which tended to commercial operation.

The analysis of slag given suggested that there was an appreciable amount of iron in the lecturer's best sample. Here, again, with iron at the prices which had ruled during the last year or two it was very important that the minimum amount of iron should go into the slag. For that reason the speaker always advocated the use of the maximum amount of limestone consistent with preserving the life of the furnace lining.

MR. WOOD replied that he had no personal experience of the drop bottom, all his work having been carried out with the solid bottom; but he thought the latter was safer, especially when dealing with large quantities. The drop bottom would suffice up to, say, 5 tons a day, but they were more liable to accidents. The author's coke to iron ratio including the bed at the present time was 1: 8. They had done 1: 9 and 1: 10, but the quality of the coke obtained now was not as good as before the War. For a cupola diameter of 36-in. he used a 2 ft. 6 in. bed; with 30-in. diameter he thought 2 ft. would suffice, and for 24-in. diameter 18 in. would be adequate. It took 15 cwt. of coke to make the bed 2 ft. 6 in. above the top row of tuyeres. Forty pounds of limestone was charged to the ton of iron and produced a good fluid slag. The limestone had not much influence on the amount of iron in the slag. When more air passed into the furnace than could be taken up by the carbon in the coke than the free oxygen, it united with the iron forming oxide of iron which came out in the slag. For quantities up to 5 or 10 tons, if the metal was not required very hot, the single row of tuyeres was all right, but he advocated the double row if the metal was wanted very hot. Superheat was needed, and the metal had to pass through an incandescent zone. Iron melted at about 1,200 deg. C., but at this temperature, it would not run castings. Superheat was needed, and this was obtained from the incandescent coke, which lay between the top of the melting zone and the lower tuyeres. The greater the depth of this incandescent coke, the hotter the iron.

Replying to a question put by Mr. Masters, MR. WOOD said that when relining a furnace, fireclay grouting was used for filling the joints between the bricks. The bottom or hearth was made up with broken bricks and ganister, and was about 5 in. thick.

Hollow Cast Iron Bricks.

MR. SHERBURN said he observed that the cast-iron blocks were brought down very low in the furnace lining. He was sorry Mr. Wood had not given more details, because it suggested unconventional practice. They appeared to be filled internally with bricks, and it would be interesting to know how long the blocks would last before the exposed surface was cut away by the furnace action and needed replacement.

MR. WOOD said the inside was filled up with old bricks which had come out of the old lining and ganister. The bottom two courses would last six or eight months, the others would last twelve months, with the exception of those in front of the charging door, which had to be replaced three or four times a year. These bricks were just over 1 in. in section and set with any cementing material.

MR. SHERBURN: Do you put them in without anything on the joint?

Answering Mr. Masters, MR. WOOD said they put in a new bottom every five weeks. It would last longer, but if it became too hard it was difficult to remove. With regard to the amount of coke in the bed, if he were using a 36-in. cupola he would put 2 ft. 6 in. on for the first day and watch the time of melting. If it was 15 or 20 minutes before the metal made its appearance it would be obvious that there was too much coke, and the next day modification would be made, but no definite rule could be established. When using the bottom tuyeres to remove obstruction the blast pressure is not reduced.

MR. PELL suggested that if the obstruction was low down so that the top tuyeres had to be closed, and the blast pressure continued at, say, 14 ozs., the effect would be to chill the charge above instead of melting it.

MR. WOOD replied that he would not close all the four top tuyeres.

Drop Bottom Cupolas.

MR. PELL said he had for many years worked three drop bottom cupolas, and found they were just as safe as solid bottoms, provided the bottom was installed properly. Much depended upon the

* This Paper was given in our issues of April 20 and 27, 1922.

holding capacity of the cupola, but he would have no fear in using the drop bottom when melting 50 tons a day, provided there was a good attendant. There should be a reasonable depth of sand underneath. Usually when the bottom was installed in a 5-ton furnace, half red-sand and half black-sand was used and a leakage was unknown. If an accident happened which could not be overcome, the whole charge could be easily removed.

MR. HOGG inquired at what distance from the cupola would Mr. Wood advise putting the blower He got excellent results with a blower 14 to 15 yards away. Taking everything into consideration he was strongly in favour of having a fan at that distance.

MR. WOOD said his blower was about 30 yards away from the cupola, but he did not think the distance mattered very much so long as the delivery was maintained, and the air was not blown directly into the cupola. A wind belt of sufficient area to hold an accumulation of air should be provided; this would act as a buffer and soften the blast.

THE CHAIRMAN (Mr. W. H. Meadowcroft) said, personally, he approved of the drop bottom provided the furnace was of correct design, but drop bottom furnaces existed where insufficient room was allowed for the sand supplemented by a badly-fitting door. His firm had installed a small furnace, 2 ft. 3 in. diameter, with a drop bottom. There were 6 in. to 7 in. of sand, and the door had a few perforations in it. A layer of coke was put on the door, and the height made up by tightly ramming black sand on to it.

In a small foundry he had got good results with one set of tuyeres. With plenty of tuyere area and a soft blast one could not go far wrong.

To his mind the most interesting thing in the Paper was the cast-iron blocks. He had used them for a number of years, but never so low down.

In moving a vote of thanks, Mr. Sherburn said more was generally taken for granted in cupola practice than in any other aspect of foundry work. As to the controversy regarding drop bottoms and solid bottoms, the former was by far the better labour-saving proposition, and the only advantage of the latter was the greater security of the hearth, which, however, did not balance its disadvantages.

The motion was seconded by Mr Pell, and passed unanimously.

Deaths.

MR. C. W. DUNLOP, J.P., a director and former chairman of the Bowling Iron Company, Limited, died recently.

MR. OWEN OWENS, of the Lutterworth Agricultural Engineering Company, Limited, died recently in his thirty-ninth year.

MR. N. V. WALLACE, departmental manager to William Hunt & Sons, The Brades, Limited, of Birmingham, died recently.

MR. C. A. HOUFTON, chairman of the Mansfield Engineering Company, Limited, of Mansfield, died recently at the age of sixty years.

MR. ALEXANDER FREW, a partner in the firm of Frew Brothers & Company, wire rope manufacturers, of 90, Dobbies Loan, Glasgow, died recently.

MR. L. S. STARRETT, founder and president of the L. S. Starrett Company, manufacturers of machinists' precision tools, Athol, Mass., U.S.A., died recently.

MR. T. BAKER, head of the firm of John Baker & Sons, Limited, crucible steel makers, of Monmouth Works, Harmer Lane, Sheffield, died recently at the age of 68 years.

MR. JOHN HILL, who died on May 10, at his residence in St. Jude's Road, Wolverhampton, was for many years connected with the firm of John Hill & Sons, Stourbridge.

MR. JOHN TEMPLE, of Liverpool, died on May 17. Eighty-three years of age, he was the son of a Colne banker. He entered the telegraph service at Leeds when a youth and assisted on the "Agamemnon" during the laying of the first Atlantic telegraph cable, and was also third engineer in charge of the expeditions on the "Great Eastern," retiring from the regular service of the Telegraph Construction Company after the successful laying of the two cables. He settled in Liverpool, and rapidly assumed a prominent position in the commercial life of the city. He was managing director and chairman of the Warrington Wire Rope Works, Limited, and a director of the Horden Collieries, Limited, and the North Brancepeth Coal Company, Limited.

Company News.

Monk Bridge Construction Company, Limited.—Capital £4,000. Constructional engineers, etc. Registered office: York.

Summerlee Iron Company, Limited.—Credit balance for nine months, including amount brought in, £67,941; further ordinary dividend, 5 per cent., free of tax; carry forward, £19,941.

Falvey & Parker, Limited.—Capital £1,000. Engineers, etc. Permanent directors: M. J. Falvey and H. J. Parker. Registered office: 28, Kingsdown Avenue, Ealing, W.13.

William Morrison & Sons (Leith), Limited.—Capital £20,000. Engineers, wire weavers, etc. Directors: W. and J. B. Morrison. Registered office: 30, Jane Street, Leith Walk, Edinburgh.

Sanders, Kennedy & Company, Limited.—Capital £5,000 in £1 shares (4,000 cumulative preference and 1,000 ordinary). Engineers. Registered office: Market Street, Highbridge, Somerset.

F. English, Limited.—Capital £5,000. Manufacturers of machinery, tools, etc. Directors: F. English (chairman and permanent director) and H. R. Ketley (secretary). Registered office: 3, Beaumont Terrace, Bournemouth.

British Thomson-Houston Company, Limited. — Profits, £509,259; brought forward, £225,891; depreciations, reserves, etc., £160,000; dividend for year, 6 per cent., free of tax, on ordinary; carry forward, £230,704.

H. Taylor, White & Company, Limited.—Capital £4,000 in £1 shares. Engineers. Directors: H. M. Burton and H. A. Taylor. Secretary: R. J. Robinson. Registered office: Roman Works, Claxton Grove, Fulham, S.W.

T.O.M. Company, Limited.—Capital £15,000. Manufacturers of motors, motor vans or wagons, etc. Directors: Sir Walter P. Townley, K.C.M.G., H. E. L. Owen, and K. H. Macartney. Registered office: 6, Princes Street, Hanover Square, W.

Allen Everitt & Sons, Limited. — Profit, £29,710; brought forward, £4,537; available, £34,247; depreciation, £11,885; reserve, £469; debenture interest, £3,978; final dividend, 7½ per cent. per annum, free of tax, making 7½ per cent., free of tax; carry forward, £4,714.

John Fowler & Company (India), Limited.—Capital £1,000, to acquire the branch business carried on by John Fowler & Company (Leeds), Limited, in India. Engineers. Directors: A. Fowler, C. H. Fowler, E. G. Pelly, and T. Davis. Registered office: 113, Cannon Street, London, E.C.

Glaslyn Foundry & Engineering Company, Limited.—Capital £5,000 in £1 shares (4,000 10 per cent. cumulative participating preference and 1,000 ordinary), to acquire the business carried on by C. Williams, sen., as Charles Williams & Sons, and to adopt an agreement with the said vendor and the North Wales Industries, Limited. Registered office: Glaslyn Foundry and Engineering Works, Portmadoc.

Siemens Brothers & Company, Limited. — Profit, £200,993; brought forward, £437,218; interim dividend, 1s. per share, £75,000; corporation profits tax for 1920 and 1921, £29,100; payments on account of excess profits duty, £100,000; profit available, £434,112; half year's dividend to December 31, 1921, on 10 per cent. cumulative preference, £15,000; final ordinary dividend, 1s. per share, making 10 per cent. for year, free of tax, £75,000; write off book value of s.s. "Faraday," £10,000; carry forward, £334,112.

Personal.

MR. R. FOULSTON, a director of Mellows & Company, Limited, Sheffield, left £2,327.

MR. R. MCLEAN has been appointed as agent of the Great Indian Peninsular Railway in India.

MR. J. R. COATS, chief engineer of the Calcutta Municipal Corporation, is in this country on six months' leave.

MR. G. K. LEET, private secretary to Judge Gary, has been elected secretary of the United States Steel Corporation.

THE LATE Mr. P. Wood, formerly chairman of Lumby, Son & Wood, Limited, boiler makers, Halifax, left £3,485.

THE late Mr. H. H. L. Lewis, managing director of Lewis & Lewis, Limited, the Foundry, Townmead Road, Fulham, S.W., left £29,926.

MR. R. EDWARDS has been appointed a Junior Inspector of Coal Mines, Inspector Metalliferous Mines, and an Inspector of Factories and Workshops.

MR. W. WEBB, of Shakespeare & Webb, metal merchants, of 17, Philpot Lane, London, E.C., was the recipient, on May 17, of a presentation, to commemorate his fiftieth year in connection with the London Metal Exchange. The presentation was made by Sir Cecil Budd, chairman of the Exchange.

IRON AND STEEL MARKETS.

Pig-iron.

Conditions in the pig-iron trade remain practically unchanged since last reported, market movements everywhere being suspended pending a settlement of outstanding labour disputes, of which at present there are no very hopeful signs. In the West of Scotland trading operations, as concerns home consumers of pig, continue stagnant, but it is noteworthy that a few transactions on forward account are occasionally reported, and so far there has been no further reduction of the limited number of furnaces in blast. There is a tendency among Scottish smelters to restrict dealings to June deliveries only, the improvement in export business and home prospects at that date apparently justifying some idea of stiffening prices in the near future. At Birmingham this week Midland makers report that some iron is going into stock, but there is a confident feeling that a revival of demand may be anticipated shortly, and consequently prices still rule firm. On Tees-side the business passing in Cleveland iron is still negligible, the home demand remaining very quiet, with consumers mostly buying only hand-to-mouth quantities. Foreign inquiry is also slowing down to some extent, shipments of pig-iron from the Port of Middlesbrough during May up to and including the 23rd inst., having amounted to 23,468 tons, as compared with 29,060 tons in the corresponding period of April. In Cleveland iron trade circles much disappointment is expressed at the inadequate reductions in transport rates. Earlier impressions as to the effect of the revision of these changes have had to be considerably modified. Closer examination of the figures now reveal that the economy effected per ton of pig-iron is not more than about fivepence or sixpence, which is, of course, of no use whatever to an industry producing at a loss.

Business in the East Coast hematite market continues very inactive, and the closing down of the two furnaces on this iron at Messrs. Whitwell's Thornaby works is a pretty clear indication of existing conditions. Hematite quotations are weak and irregular.

Finished Iron.

The unfortunate breakdown of negotiations for a settlement of the engineers' dispute last week has had a further adverse effect upon business in the finished iron trade, and markets for this material are virtually lifeless. In South Staffordshire a very large proportion of the productive capacity of the district is still unemployed, with little prospect of revival until costs of manufacture can be further reduced. The slump in the shipbuilding industry is reflected in the quiet conditions now prevailing in the chain and cable branch, makers of this special quality of material experiencing a very slack time. Similar conditions are noted in nut and bolt iron, for which quotations remain officially at £10 2s. 6d., with fencing qualities at £10 5s., though it is stated that substantial orders for this material could be placed on somewhat lower terms. Makers of crown bars are still in an extremely difficult position, three or four well-known producing plants in the Black County still remaining idle, because it would not pay them to make such bars at the price obtainable, or, in fact, at £11 10s., according to some of them, and yet there are reports of such iron being offered by makers at £11. Marked bars remain firm at £13 10s. (net f.o.t. works), but here again producers' order books are by no means so well filled as could be desired, buyers evidencing considerable caution in placing forward business.

Steel.

The outlook in the steel trade generally is very difficult to define with exactitude, some branches of the industry still making a fair show of activity, while others have little or no work in hand at the moment, especially in the latter case, where makers are wholly dependent for orders upon the engineering departments. It is remarked that railway companies are beginning to order on a more liberal basis for their requirements, and this should have a stimulating effect on the steel industry. The numerous recent accidents on various railways have all had an element of doubt, and the true solution is probably long usage without thorough overhauling and replacement, and also to the class of material turned out in the war period, especially in steel products. The railway companies can be large buyers, and a strong policy on their part in this direction would stimulate industries and create traffic for them from which they would later reap the benefit by restoring confidence in trade generally.

Scrap.

In common with every description of raw material the demand for iron and steel scrap is on a much diminished scale, and though at Middlesbrough a few very moderate sized parcels are changing hands, here and there business on anything like a normal scale is out of the question. The following are approximate current prices, all delivered at works: Heavy steel scrap, 62s.; steel turnings and cast-iron borings, each 45s.; heavy wrought-iron piling scrap, ordinary quality, 62s. 6d.; ditto, bushelling, 62s. 6d.; ditto, heavy forge, 65s.; cast-iron machinery scrap in handy pieces, 82s. 6d. to 85s.; cast-iron scrap (ordinary quality), 75s. to 77s. 6d. There is no business passing either in heavy wrought or cast-iron scrap. In the Midlands, however, there is still a fair demand for heavy steel scrap and heavy steel turnings, and the prices are firm at 52s. 6d. to 57s. 6d. for steel scrap and 38s. 6d. to 41s. 6d. for steel turnings, f.o.r.

Tinplates.

The market for tinplates has perceptibly slackened down of late, and business during the current week has been uneventful, buyers evidently holding off in anticipation of lower prices. Speculative sales are reported below maker's figures, which, however, for the present continue fairly firm. Coke tins, I C 14 x 20 and 29 x 20, 19s. basis has been accepted for June delivery, net, f.o.b. Wales, although makers generally are asking about 3d. a box more than this. There is a moderate demand for wasters, and prices are fairly steady as follows:—C W 14 x 20, 108 lbs., 17s. to 17s. 3d. per box; C W 28 x 20, 216 lbs., 34s. 3d. to 35s. per box; X W 28 x 20, 272 lbs., 39s. to 39s. 9d. per box; C W 14 x 18½, 110 lbs., 17s. 6d. to 17s. 9d. per box; C W 20 x 10, 156 lbs., 23s. to 23s. 3d per box. All net, f.o.t. at works.

Metals.

Copper.—Price fluctuations in the standard copper market during the current week have been confined within very narrow limits, the tone throughout indicating, if anything, a steadily advancing tendency in values. The business transacted each day has been on a substantial scale suggestive of a revival of consumptive demand, the Continent booking fairly extensive orders on forward account, while America is also buying more freely than has been noted of late. Refined copper continues firm, with electrolytic selling at round about £68 10s. and wire bars £70 10s. Closing prices.—*Cash*: Wednesday, £62 5s.; Thursday, £62 7s. 6d.; Friday, £62 5s.; Monday, £62 7s. 6d.; Tuesday, £62 12s. 6d. *Three months*: Wednesday, £62 12s. 6d.; Thursday, £62 15s.; Friday, £62 13s. 9.; Monday, £62 15s.; Tuesday, £63.

Tin.—The tendency of values for standard tin recently has been somewhat irregular, advices from the East reporting steady sales in that quarter, with a fair amount of buying on account of American interests. The home demand continues limited in volume, many of the Welsh tinplate mills having some difficulty in obtaining fresh orders, while America, with labour troubles of her own, is not buying as freely as usual. It would appear that the holders of the large stocks of tin in the East are adopting the policy of gradually making some headway with the liquidation of their stocks. During 1921 the export of tin and tin ore from the Federated Malay States showed a small decrease compared with the previous year, although the value was down by nearly 50 per cent. The figures were 46,127 tons in 1921, valued at £5,828,372; and 46,949 tons in 1920, valued at £10,316,737. Closing prices.—*Cash*: Wednesday, £150 10s.; Thursday, £151; Friday, £150 7s. 6d.; Monday, £151; Tuesday, £152 2s. 6d. *Three months*: Wednesday, £152; Thursday, £152 10s; Friday, £151 15s.; Monday, £152 5s.; Tuesday, £153 10s.

Spelter.—There has been little change to note in the market for this metal, values remaining firm and steady, although consumers' demands have been on a restricted scale. Imports of spelter are arriving more freely, and unless consumption is increased must have a weakening effect upon values. Closing prices.—*Ordinary brands*: Wednesday, £27 12s. 6d.; Thursday, £27 12s. 6d.; Friday, £27 17s. 6d.; Monday, £28 5s.; Tuesday, £28 2s. 6d.

Lead.—The market for soft foreign pig continues strong owing to restricted supplies, but a shortage of the metal may have some effect upon June deliveries, most of the American lead shipments going to Continental ports. English lead maintains its firmness. *English closing prices*: Wednesday, £26 5s.; Thursday, £26 5s.; Friday, £26; Monday, £26; Tuesday, £26 5s.

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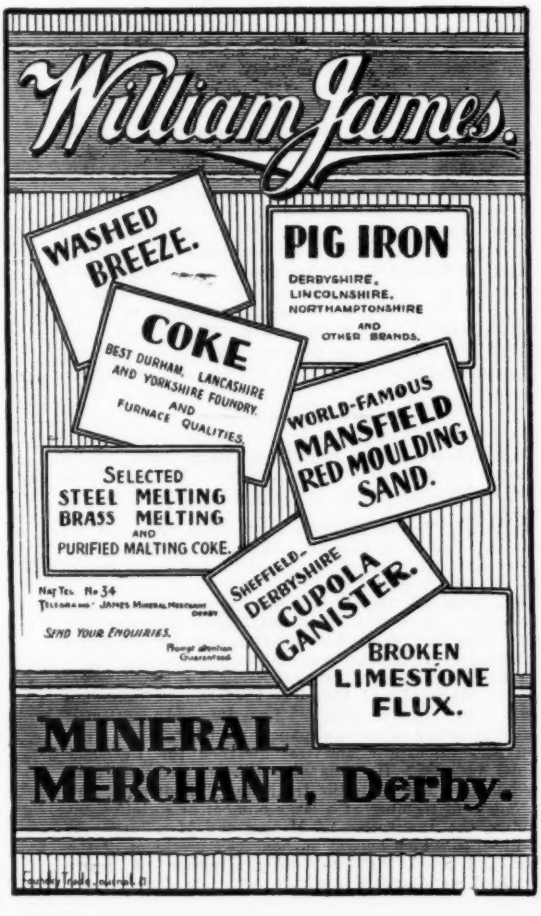
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Trade Talk.

JIGS, LIMITED, 3, Berners Street, London, W.1, have removed to 132, Long Acre.

MR. J. W. RUSSELL, electrical engineer, 49a, Fore Street, Hertford, has established a branch at Ware.

MR. J. H. STUDLEY, iron, steel and metal merchant, of 25, Bond Street, Leeds, has removed to Vicarage Chambers, 9, Park Square, Leeds.

THE STEEL WORKS at Newcastle (N.S.W.) have been closed down in accordance with the recently announced policy of the Broken Hill Proprietary Company.

ALFRED HERBERT, LIMITED, of Coventry, have established a branch at 25, de Mayo, No. 267, Buenos Aires, under the management of Mr. Colin York.

W. H. ALLEN, SONS, & COMPANY, LIMITED, Queen's Engineering Works, Bedford, have removed their London office to 5, Victoria Street, Westminster, S.W.1.

WALTERS, DOBSON & COMPANY, engineers, Sheffield, have appointed Mr. F. Kent as manager of the branch they have established at Priory Road, High Wycombe.

FINLAY & HODGSON, 147, Leadenhall Street, E.C.3, have been appointed London agents for Goodwin & Company, Limited, of the Scottish Steel & File Works, Neepsend, Sheffield.

THE YORKSHIRE COMMERCIAL MOTOR COMPANY, Pepper Road, Hunslet, Leeds, have decided to revert to the old title of the company, namely, the Yorkshire Patent Steam Wagon Company.

A PARTY of business men on Thursday of last week made an inspection of the works of G. H. Gledhill & Sons, Limited, Halifax, and witnessed the manufacture of time recorders and cash tills.

AFTER having restarted two furnaces four months ago, Wm. Whitwell & Company, Limited, Thornaby-on-Tees, have decided to damp them down owing to the continued depression in the iron trade.

THE CONSOLIDATED PNEUMATIC TOOL COMPANY, LIMITED, Egyptian House, 170, Piccadilly, London, W.1, have removed their Bombay office to Amarchand Building, Ballard Road, Fort Bombay.

J. H. TUCKER & COMPANY, LIMITED, electric light and power accessories manufacturers, King's Road, Tyseley, Birmingham, have removed their London branch from 217, Shaftesbury Avenue, to 101, Dean Street, W.

ETCHELLS, CONGDON & MUIR, LIMITED, Alexander Wright & Company, Limited, the Falkirk Iron Company, Limited, and C. M. Powell Bros. have joined the Federation of British Industries.

MR. J. DONALD has acquired the business of the Reading Iron Company, Limited, King Street, Reading. Mr. Donald was a director and manager of the firm, which will in future be carried on under the style of the Reading Iron Company.

THE CAMBRIAN ELECTROLYTIC ZINC COMPANY, LIMITED, 80, Bishopsgate, London, E.C.2, have been formed to acquire the zinc and lead mines of the Lisburne Development Syndicate, Limited, and the Welsh Mines Corporation, Limited.

MR. C. L. MACCARTHY, 48, Foster's Buildings, Sheffield, who, as previously reported, has been appointed agent for Milner Hurd's Patents Company, Limited, will also represent John Russell & Company, Limited, the Butterley Company, Limited, and Sutcliffe Bros. & Bryce, Limited.

THE SHAREHOLDERS of the Controla Engineering Company, Limited, have decided that the company cannot, by reason of its liabilities, continue to carry on its business, and that the company be wound up voluntarily. Mr. F. H. Hudson, 8, Newhall Street, Birmingham, is the liquidator.

AN agreement has been come to between the Scotch electrical engineering employers and their men that, in view of the reductions in wages which have already taken place this year, the existing rate of pay should be stabilised till the close of the year, when it will be open to either party to review the situation.

MR. J. T. MIDDLEHAM, secretary and director of Hadfields, Limited, died last week. Mr. Middleham, who was 56 years of age, was one of the old members of the staff of Hadfields, and had gradually risen in the service to occupy some of the most important positions under the company. He was appointed secretary of the company a considerable time ago, and for the last few years he had also been a director.

MR. F. GILL has been elected president of the Institution of Electrical Engineers for the year 1922-23, with Dr. W. H. Eccles and Mr. A. A. Campbell Swinton as vice-presidents. The honorary treasurer is Sir James Devonshire, and the ordinary members of council are Mr. J. W. Beauchamp, Mr. R. A. Chattock, Mr. F. W. Crawter, Mr. D. N. Dunlop, Major K. Edgcumbe, Mr. A. F. Harmer, and Mr. W. B. Rawlings.

THE AUSTRALIAN CUSTOMS DEPARTMENT have approved of the following tariff decisions: Electric machines and appliances for the production and distribution of electricity from brown coal, including lighting arresters, frequency absorbers and parts, switch gear, transformers, etc., may be admitted under Item 174, free under the British preference tariff, 5 per cent. under the intermediate and 10 per cent. under the general tariff; wire, ribbon, hardened and tempered, for use in the manufacture of surveyors' measuring chains, Item 404, free, free, 10 per cent.

DURING last winter parties of Newcastle Quaysiders paid visits to the Newcastle and Gateshead Gas Works, Team By-Product Works, Armstrong, Whitworth & Company (Locomotive Works), North Walbottle Colliery, Haggie Brothers Rope Works, and Sowerby's Glass Works, Gateshead. The winter session was brought to a close recently when a dinner was held, at which over 100 attended. Opportunity was taken upon that occasion to inaugurate a society having for its object the inquiry into matters of interest to Quaysiders by visits to various places, and in other ways to gain knowledge which may prove helpful to those concerned.

The President Returning Home.

Mr. Oliver Stubbs, president of the Institute of British Foundrymen, who was guest at the dinner of the New England Foundrymen's Association in Boston on May 12, stated that the gradually increasing friendship and understanding between the American Foundrymen's Association and the Institution of British Foundrymen was going to go a long way towards cementing the friendship between the two nations. The previous day was spent in Worcester, Mass., where, under the guidance of Dr. Ira N. Hollis, president of the Worcester Polytechnic Institute, he visited the plants of the Morgan Construction Company and of Crompton and Knowles Loom Works. In Boston, A. B. Root, mechanical engineer of Hunt-Spiller Corporation, and past-president of the New England Foundrymen's Association, acted as host for Mr. Stubbs' entertainment. Plant inspection here was made at the Walworth Manufacturing Company, and at the Saco-Lowell shops at Newton Upper Falls. At the dinner Mr. Stubbs laid particular emphasis on the cordial treatment he had received at plants in various parts of the country. He said he was much impressed with the up-to-date character of the shops in New England, and that he was especially pleased with the friendly spirit prevailing between the managements and the workers. Reviewing his trip of plant inspection in this country, which is brought to an end by his visit in Boston, Mr. Stubbs said that he thought the United States was ahead of England on small casting work where large production is secured. He said he found better finish on machine-cast pieces in the States than in England, but that he felt the finish of heavy work was better in English plants than in American. A spirit of co-operation and frankness is finally being achieved in the foundry field, both in England and America, and Mr. Stubbs feels that the future relations between the foundrymen of these two countries will become closer and closer as time goes on. Already the associations in the two countries are working along similar lines on standardisation matters. Mr. Stubbs then left Boston for New York, and sailed for England in time to preside at the Birmingham Conference of the Institution of British Foundrymen.

SIR WALTER ROPER LAWRENCE, BART., who was a director of Siemens Bros. & Company, Limited, from 1907 to 1914, has again been elected a director of the company.

MR. H. LEATHERBARROW, managing director of Barrow, Brown & Company, Limited, engineers and merchants, Bangkok, Siam, is visiting this country at the end of the month.

SIR BERNARD MALLET has been appointed an additional member of the Panel, established in connection with Part II. (Prevention of Dumping) of the Safeguarding of Industries Act.

PROFESSOR HENRY MARION HOWE, of the University of Harvard and Emeritus Professor of Columbia University, died recently. The deceased gentleman was the author of several papers read before the Iron and Steel Institute, and was awarded the Bessemer medal in 1895. He was also Elliott Cresson gold medallist of the Franklin Institute, Philadelphia, and an honorary member of a large number of societies, including the Institution of Mining and Metallurgy, in addition to which he was an hon. vice-president of the Iron and Steel Institute, and the author of many standard metallurgical works.